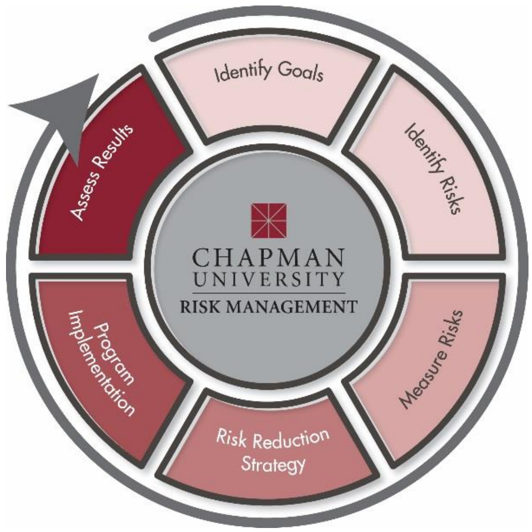
CHAPMAN UNIVERSITY
RISK MANAGEMENT

Environmental Health and Safety

Chemical Hygiene Plan



2021

Chapman University Environmental Health & Safety – (714) 628-2888
Chapman University Risk Management – (714) 532-7794
Chapman University Fire Safety - (714) 744-7875
Chapman University Public Safety – (714) 997-6763

Contents

1.0 PURPOSE

The purpose of the Chemical Hygiene Plan (CHP) is to provide procedural guidelines for prudent work practices in the handling, storage, and use of chemicals in the laboratory and to protect laboratory workers from the potential health hazards of the chemicals they encounter in the workplace.

2.0 APPLICABILITY AND SCOPE

This program applies to all persons who handle hazardous chemicals in Chapman University-owned or operated laboratories. The CHP does not apply to research involving exclusively radiological materials, radiation producing machines, biological materials, or lasers. Research involving more than one type of hazard must comply with all applicable regulatory requirements.

The information presented in the CHP is not intended to be all inclusive. Departments, divisions or other work units engaged in work with potentially hazardous chemicals that have unusual characteristics or are otherwise not sufficiently covered in the written CHP, must supplement the document with work-site specific Standard Operating Procedures (S.O.P) that describes the hazards and how to mitigate their risks, as appropriate. Such documents must receive prior approval from the PI/Laboratory Supervisor and/or Chapman University's Environmental Health and Safety (EH&S) office. For information on specific chemical safety topics not covered in the CHP, please contact the EH&S at ehs@chapman.edu.

3.0 REGULATIONS AND STANDARDS

Implementation of the necessary work practices, procedures, and policies outlined in this CHP is required by the following:

- Title 8, California Code of Regulations (CCR), Section 5191, "Occupational Exposure to Hazardous Chemicals in Laboratories"
- Title 8, CCR, Article 110, Section 5200-5220 regulated carcinogens including, but not limited to: Section 5203 "Carcinogen Report of Use Requirements" Section 5209, "Carcinogens"
- Title 8, CCR, Section 5154.1, "Ventilation Requirements for Laboratory – Type Hood Operations"

Other applicable regulations include those promulgated by the U.S. Department of Labor including 29 CFR 1910.1450 "Occupational Exposure to Hazardous Chemicals in Laboratories" (the "Laboratory Standard"). EH&S will review and evaluate the effectiveness of this Plan at least annually and update it as necessary.

4.0 DEFINITIONS

CHP – Chemical Hygiene Plan-Is a written program developed and implemented by the employer which sets procedures, equipment, personal protective equipment and work practices that are capable of protecting employees from health hazards of hazardous chemicals used in that particular work place.

Corrosive- a chemical that causes visible destruction of or irreversible alterations in living tissue by chemical action at the site of contact. For example, a chemical is considered to be corrosive if, when tested on the intact skin of albino rabbits by the method described by the U.S. Department of Transportation in appendix A to 49 CFR part 173, it destroys or changes irreversibly the structure of the tissue at the site of contact following an exposure period of four hours.

Employee- a research staff member, technician, or student worker working with hazardous materials, employed by the University and in a position reporting to a designated supervisor.

Flammable- a chemical that falls into one of the following categories:

- Aerosol, flammable means an aerosol that, when tested by the method described in 16 CFR 1500.45, yields a flame projection exceeding 18 inches at full valve opening, or a flashback (a flame extending back to the valve) at any degree of valve opening;
- Gas, flammable means: A gas that, at ambient temperature and pressure, forms a flammable mixture with air at a concentration of 13 percent by volume or less; or
- A gas that, at ambient temperature and pressure, forms a range of flammable mixtures with air wider than 12 percent by volume, regardless of the lower limit.
- Liquid, flammable means any liquid having a flashpoint below 100 deg F (37.8 deg. C), except any mixture having components with flashpoints of 212 deg F (100 deg. C) or higher, the total of which make up 99 percent or more of the total volume of the mixture.
- Solid, flammable means a solid, other than a blasting agent or explosive as defined in § 1910.109(a), that is liable to cause fire through friction, absorption of moisture, spontaneous chemical change, or retained heat from manufacturing or processing, or which can be ignited readily and when ignited burns so vigorously and persistently as to create a serious hazard. A chemical shall be considered a flammable solid if, when tested by the method described in 16 CFR 1500.44, it ignites and burns with a self-sustained flame at a rate greater than one-tenth of an inch per second along its major axis.

Organic peroxide formers– materials that react with oxygen to form peroxy compounds (usually hydroperoxides) that are very unstable and decompose continuously. These organic peroxides are sensitive to light, heat, friction, and impact, as well as to strong oxidizing and reducing agents, and they are extremely flammable. There are four main groups of peroxide formers:

- Ethers with primary and/or secondary alkyl groups attached to the oxygen, including open chain and cyclic ethers, acetals, and ketals.
- Hydrocarbons with allylic, benzylic, or propargylic hydrogens.
- Conjugated dienes, eneynes, and diynes.
- Saturated hydrocarbons with exposed tertiary hydrogens.

Hazard Assessment - The process utilized to identify hazards in the workplace and to select the appropriate Personal Protective Equipment to guard people against potential hazards
Oxidizer- a chemical other than a blasting agent or explosive as defined in § 1910.109(a), that initiates or promotes combustion in other materials, thereby causing fire either of itself or through the release of oxygen or other gases. In chemistry terms, it is an agent that receives electrons from a reducing agent during an oxidation-reduction reaction.
Personal Protective Equipment (PPE)- Includes all clothing and equipment worn designed to provide protection from potential hazards to the eyes, face, hands, head, feet, ears, and extremities.
Physical Hazards- Physical hazards are identified as substances, equipment, or activities that can threaten physical safety. Physical hazards can include but are not limited to: impact (falling objects), fall hazards, extreme pressures, temperature extremes (heat/cold), radiation (ionizing and non- ionizing), noise, vibration, electrical, light (optical), welding, cutting, brazing.
Prop 65 - The Safe Drinking Water and Toxic Enforcement Act of 1986 (Prop 65) requires the Governor of the State of California to revise and republish the list of chemicals known to the State to cause cancer or reproductive toxicity. The list is available at http://www.oehha.ca.gov/prop65.html .
Reactive-(unstable) - a chemical which will vigorously polymerize, decompose, condense, or will become self-reactive under conditions of shocks, pressure or temperature.
Respiratory Protection - Equipment designed to provide protection to the wearer from potential inhalation hazards such as vapors, mists, particulates, and gases.
Student- a University student is herein defined to include any person enrolled in a research or other university course, receiving academic credit for participation in laboratory operations.
Supervisor- a University principal investigator, lab manager, senior researcher, administrative officer, or associate in charge of a laboratory, school unit, operation, or clinic where hazardous materials are used and/or stored.
Toxic- a chemical falling within any of the following categories:

- A chemical that has a median lethal dose (LD50) of more than 50 milligrams per kilogram but not more than 500 milligrams per kilogram of body weight when administered orally to albino rats weighing between 200 and 300 grams each.
- A chemical that has a median lethal dose (LD50) of more than 200 milligrams per kilogram but not more than 1,000 milligrams per kilogram of body weight when administered by continuous contact for 24 hours (or less if death occurs within 24 hours) with the bare skin of albino rats weighing between two and three kilograms each.
- A chemical that has a median lethal concentration (LD50) in air of more than 200 parts per million but not more than 2,000 parts per million by volume of gas or vapor, or more than two milligrams per liter but not more than 20 milligrams per liter of mist, fume, or dust, when administered by continuous inhalation for one hour (or less if death occurs within one hour) to albino rats weighing between 200 and 300 grams each.

University- Chapman University.
Volunteer- an individual that provides services related to hazardous materials use to the University without remuneration or compensation. This may include research assistants.

5.0 RESPONSIBILITIES

All Chapman personnel who work in laboratories have the right to be informed about the potential health hazards of the chemicals in their work areas and to be properly trained to work safely with these substances. This includes custodial staff and other personnel who work to clean and maintain laboratories.

Responsibilities for the health and safety of the campus community extend to the highest administrative levels at Chapman University. Deans and Department Heads are responsible for establishing and maintaining programs in their areas and for providing a safe and health work environment.

The day-to-day responsibility for the management of laboratory safety and adherence to safe laboratory practices rests with the PI/Laboratory Supervisor within individual laboratory units associated departments. All personnel, including PIs/Laboratory Supervisors, employees and students, have a duty to fulfill their obligations with respect to maintaining a safe work environment. Safety is everyone's responsibility.

All employees and other personnel working with potentially hazardous chemicals have the responsibility to conscientiously participate in training seminars on general laboratory safety and review and be familiar with the contents of the CHP. Those working with chemicals are responsible for staying informed about the chemicals in their work areas, safe work practices and proper personal protective equipment (PPE) required for the safe performance of their job. Failure to comply with these requirements will result in progressive disciplinary action in accordance with university policy, and may result in temporary suspension of laboratory activities until corrective action is implemented.

Chapman University Responsibilities
It is the responsibility of the Chapman University to:

- Institute and maintain the Chemical Hygiene Plan;
- Review this program annually and notify constituents of any changes;
- Assist with initial safety training for hazardous materials users and maintain records of attendance;
- Audit performance of hazardous materials users in implementing provisions of the program
- Maintain a chemical inventory

Science Safety Committee Responsibilities
The University has organized a Chapman University Science Safety Committee. This Committee is structured to be representative of the university science and technology community and its diverse constituency. The general mission of the Science Safety Committee is to:

- Develop and implement written safety programs
- Discuss and take effective action on the principal accident-causing conditions
- Develop and monitor training required to maintain a safe environment in the field of science and technology.
- Help stimulate an awareness of health and safety issues and an atmosphere of cooperation between management and workers in the sciences
- Help in identifying problems, formulating policy and procedures, monitoring and improving workplace health and safety
- Serve as a consultative body for the required annual reviews of the Chemical Hygiene Plan

EH&S and Chemical Hygiene Officer (CHO) Responsibilities

EH&S provides technical guidance to personnel at all levels of responsibility on matters pertaining to laboratory use of hazardous materials and provides consultation and guidance to the Science Safety Committee on developing and implementing the chemical hygiene plan. The CHO is a member of EH&S and, with support from other EH&S personnel, is responsible for:

- Informing PIs/Laboratory Supervisors of all health and safety requirements and assisting with the selection of appropriate safety controls, including laboratory and other workplace practices, personal protective equipment, engineering controls, training, etc.
- Having working knowledge of current health and safety rules and regulations, training, reporting requirements and standard operating procedures associated to regulated substances. Such knowledge may be supplemented and developed through research and training materials
- Working with research staff to review existing SOPs and assist with developing new SOPs for handling hazardous chemicals
- Provide technical assistance to those working in a laboratory setting
- Ensures compliance with CHP
- Assist Principal Investigators (PI’s) in developing appropriate safety precautions for new projects especially when working with materials which may pose extreme hazards
- Provides oversite for lab safety inspections, audit operations which includes the maintenance of records and notifications of corrective actions
- Assist with the appropriate selection of personal protective equipment
- Assist with assessing potential exposure issues and chemical inventory review
- Providing technical guidance and investigation, as appropriate, for laboratory and other types of accidents and injuries
- Helping to determine medical surveillance requirements for potentially exposed personnel
- Reviewing plans for installation of engineering controls and new facility construction/renovation, as requested

- Reviewing and evaluating, with the assistance of the Science Safety Committee, the effectiveness of the CHP at least annually and updating it as appropriate
- Reviews and approves hazardous materials and equipment in the purchasing system

Principal Investigators (PI's)/Supervisor Responsibilities
The PI/Laboratory Supervisor has responsibility for the health and safety of all personnel working in their laboratory who handle hazardous chemicals. The PI/Laboratory Supervisor may delegate safety duties, but remains responsible for ensuring that delegated safety duties are adequately performed. It is the responsibility of the supervisor to:

- Ensure that all persons under the supervisor's purview understand and comply with this CHP
- Identify potential hazardous conditions or operations in the lab, determine safe procedures and controls, and implement and enforce standard safety procedures
- Ensure initial training of hazardous materials users through laboratory safety course approved by EH&S
- Maintains all training records and any other recordkeeping needs (SOPs, SDSs, etc.)
- Maintain a current chemical inventory for each laboratory
- Provide easy access to Safety Data Sheets (SDSs), formerly known as Material Safety Data Sheets (MSDS)
- Prepare Standard Operating Procedures (SOP) including Safe Work Practices for all processes involving hazardous materials and particularly those with Globally Harmonized System, (GHS) ratings of "1"conducted in the facility
- Maintain all training records and other recordkeeping (SOPs, SDSs etc) in the lab safety manual for easy access
- Hold safety meetings as needed to review safety issues, best management practices or on relevant topics concerning laboratory procedures and operations.
- Ensuring the availability of all appropriate personal protective equipment (PPE) which properly fits the wearer (e.g., laboratory coats, gloves, eye protection, etc.), training on the selection, care, use and proper storage, ensuring the PPE is maintained in working order. Also, determine and document the PPE needed for each procedure; and comply with all University safety policies
- Consulting with EH&S on the use of higher risk materials, such particularly hazardous substances, or conducting higher risk experimental procedures so that special safety precautions may be taken
- Promptly notifying EH&S and/or Facilities Management should one become aware that work place engineering controls (e.g., fume hoods) and safety equipment (e.g., emergency showers/eyewashes, fire extinguishers, etc.) become bypassed, disabled or non-operational
- Promptly reporting accidents and injuries to EH&S. Fatalities and serious injuries MUST be reported to EH&S immediately to allow for compliance with the CAL/OSHA 8-hour

reporting time frame. Any doubt as to whether an injury is serious should favor reporting

- Providing funding for exposure monitoring and medical surveillance and/or medical consultation and examination for laboratory and other personnel, as required. Contact the EH&S for assistance
- Informing facilities personnel, other non-laboratory personnel and any outside contractors of potential laboratory-related hazards when they are required to work in the laboratory environment when performing repairs and renovations

Employee, Volunteer, and Student Responsibilities
All personnel in research or teaching laboratories that use, handle or store hazardous chemicals are responsible for:

- Understanding and complying with all provisions set forth in this CHP and with all appropriate Safety Manuals and Policies
- Following all laboratory safety rules, regulations, and SOPs required for the tasks assigned
- Developing good personal chemical hygiene habits, including but not limited to, keeping the work areas safe and uncluttered
- Planning, reviewing and understanding the hazards of materials and processes in their laboratory research or other work procedures prior to conducting work
- Utilizing appropriate measures to control identified hazards, including consistent and proper use of engineering controls, PPE, and administrative controls
- Gaining prior approval and consultation with PI/Laboratory Supervisor before using restricted chemicals and other materials such as particularly hazardous substances (PHS), pyrophoric chemicals, explosives and other highly hazardous materials or conducting certain higher risk experimental procedures
- Understanding the capabilities and limitations of PPE issued to them
- Completing all required health, safety and environmental training and providing written documentation to their supervisor (if required)
- Completing safety trainings provided by Chapman University
- Participating in the medical surveillance program, when required
- Informing the PI/Laboratory Supervisor of any work modifications ordered by a physician as a result of medical surveillance, occupational injury or exposure
- Immediately reporting all accidents and unsafe conditions to the PI/Laboratory Supervisor
- Attending required safety meetings regularly and reviewing information pertinent to safety
- Comply with all University safety policies

6.0 HAZARD COMMUNICATION

Regulatory Requirements

Chapman is responsible for providing information about the hazardous substances in our workplace, the associated hazards, and the control of these hazards, through a comprehensive hazard communication program that is summarized below. Chapman has an established Hazard Communication Program that complies with the Cal/OSHA Hazard Communication Standard, Title 8 CCR 5194. The purpose of the Hazard Communication Program is to ensure that all employees and, upon request, their personal physicians, have the right to receive information regarding the hazardous substances to which they may have been exposed at work. The requirements of the Hazard Communication Program apply to laboratory environments at Chapman University due to the potential for large scale experiments and for activities that may occur outside of areas where engineering controls are available. Proper hazard communication involves the active participation of the PI/Lab Supervisor, the EH&S Chemical Hygiene Officer, and the Laboratory Safety Director/Administrator, who are each responsible for providing consultation and safety information to employees working with hazardous chemicals.

List of Hazardous Substances

All labs are required to keep their chemical inventory updated for each hazardous substance and compressed gas in their possession, and specific information on any associated health or safety hazards must be made readily available to all laboratory personnel, typically through Safety Data Sheets (SDS).

Hazard Determination

PIs/ Laboratory Supervisors are responsible for verifying if any items on their chemical inventory are subject to the requirements of the hazard communication regulation.
The term "hazardous substance" refers to any chemical for which there is scientific evidence that acute or chronic health effects may occur following exposure. Hazardous substances may include, but are not limited to, those chemicals listed in the following:

- "The Hazardous Substance List", prepared by the Cal/OSHA Director 8CCR339
- "Toxic and Hazardous Substances, Air Contaminants", 8CCR5155
- "Threshold Limit Values for Chemical Substances in the Work Environment", ACGIH, 2012
- Most Recent "Annual Report on Carcinogens", NTP
- "IARC Monographs on the Identification of Carcinogenic Hazards to Humans", IARC, WHO
- SDSs for reproductive toxins and cancer causing substances
- "Chemicals Known to the State to Cause Cancer or Reproductive Toxicity" (Proposition 65), 27CCR27001.

Inventory items found on the above lists are subject to the requirements outlined below.

Safety Data Sheets (SDS)

A SDS must be available for each hazardous substance in a laboratory's chemical inventory. SDSs are available from the Chapman University online SDS library. PIs/Laboratory Supervisors are responsible for keeping SDSs current and making them available to all laboratory personnel. SDSs must be in a central location that can be accessed immediately in the event of an emergency. Electronic copies may be kept in a file on a group drive, or hard copies maintained in a central location in the laboratory. New chemical substances synthesized or produced in a laboratory, and used or shared outside of a laboratory suite, require the preparation of an SDS for each synthesized substance. Contact EH&S for more information on preparing new SDSs. The SDS may be obtained from EH&S, the Senior Lab Supervisor, the manufacturer, the electronic Chemical Inventory System, or from the internet.

New Global Harmonization System (GHS) requires the standardization of SDSs. The minimum information required for an SDS is:

1. Identification of the substance or mixture and the supplier
    a. GHS product identifier
    b. Other means of identification
    c. Recommended use of the chemical and restrictions use
    d. Supplier's details (including name, address, phone number, etc.)
    e. Emergency phone number
2. Hazards Identification
    a. GHS classification of the substance/mixture and any national or regional information
    b. GHS label elements, including precautionary statements. (Hazard symbols may be provided as a graphical reproduction of the symbols in black and white or the name of the symbol, e.g., flame, skull and crossbones.) Symbols are required to be in a red border/red diamond
    c. Other hazards which do not result in classification (e.g. dust explosion hazard) or are not covered by the GHS
3. Composition/Information on ingredients
    a. Substance
        i. Chemical identity
        ii. Common name, synonyms, etc.
        iii. CAS number, EC number, etc.
        iv. Impurities and stabilizing additives which are themselves classified and which contribute to the classification of the substance
    b. Mixture
        i. The chemical identity and concentration or concentration ranges of all ingredients which are hazardous within the meaning of the GHS and are present at or above their cutoff levels
4. First aid measures

    a. Description of necessary measures, subdivided according to the different routes of exposure, i.e., inhalation, skin and eye contact, and ingestion
    b. Most important symptoms/effects, acute and delayed
    c. Indication of immediate medical attention and special treatment needed, if necessary
5. Firefighting measures
    a. Suitable (and unsuitable) extinguishing media
    b. Specific hazards arising from the chemical (e.g., nature of any hazardous combustion products)
    c. Special protective equipment and precautions for firefighters
6. Accidental release measures
    a. Personal precautions, protective equipment and emergency procedures
    b. Environmental precautions
    c. Methods and materials for containment and cleaning up
7. Handling and storage
    a. precautions for safe handling
    b. Conditions for safe storage, including any incompatibilities
8. Exposure controls/personal protection
    a. Control parameters, e.g. occupational exposure limit values or biological limit values
    b. Appropriate engineering controls
    c. Individual protection measures, such a personal protective equipment
9. Physical and chemical properties
    a. Appearance (physical state, color, etc.)
    b. Upper/lower flammability or explosive limits
    c. Odor
    d. Vapor pressure
    e. Odor threshold
    f. Vapor density
    g. pH
    h. Relative density
    i. Melting point/freezing point
    j. Solubility(ies)
    k. Initial boiling point and boiling range
    l. Flash point
    m. Evaporation rate
    n. Flammability (solid, gas)
    o. Partition coefficient: n-octanol/water
    p. Auto-ignition temperature
    q. Decomposition temperature
    r. Viscosity

10. Stability and reactivity
    a. Chemical stability
    b. Possibility of hazardous reactions
    c. Conditions to avoid (e.g., static discharge, shock or vibration)
    d. Incompatible materials
    e. Hazardous decomposition products
11. Toxicological information
    a. Concise but complete and comprehensible description of the various toxicological (health) effects and the available data used to identify those effects, including:
        i. Information on the likely routes of exposure (inhalation, ingestion, skin and eye contact)
        ii. Symptoms related to the physical, chemical and toxicological characteristics
        iii. Delayed and immediate effects and also chronic effects from short- and longterm exposure
        iv. Numerical measures of toxicity (such as acute toxicity estimates)
12. Ecological information
    a. Eco-toxicity (aquatic and terrestrial, where available)
    b. Persistence and degradability
    c. Bio-accumulative potential
    d. Mobility in soil
    e. Other adverse effects
13. Disposal considerations
    a. Description of appropriate disposal containers to use
    b. Recommendations of appropriate disposal methods to employ
    c. Description of the physical and chemical properties that may affect disposal activities
    d. Language discouraging sewage disposal

Any special precautions for landfills or incineration activities

14. Transport Information
    a. UN Number
    b. UN Proper shipping name
    c. Transport hazard class(es)
    d. Packing group, if applicable
    e. Marine pollutant (Yes/No)
    f. Special precautions which a user needs to be aware of or needs to comply with in connection with transport or conveyance
15. Regulatory Information
    a. Safety, health and environmental regulations specific for the product in question.

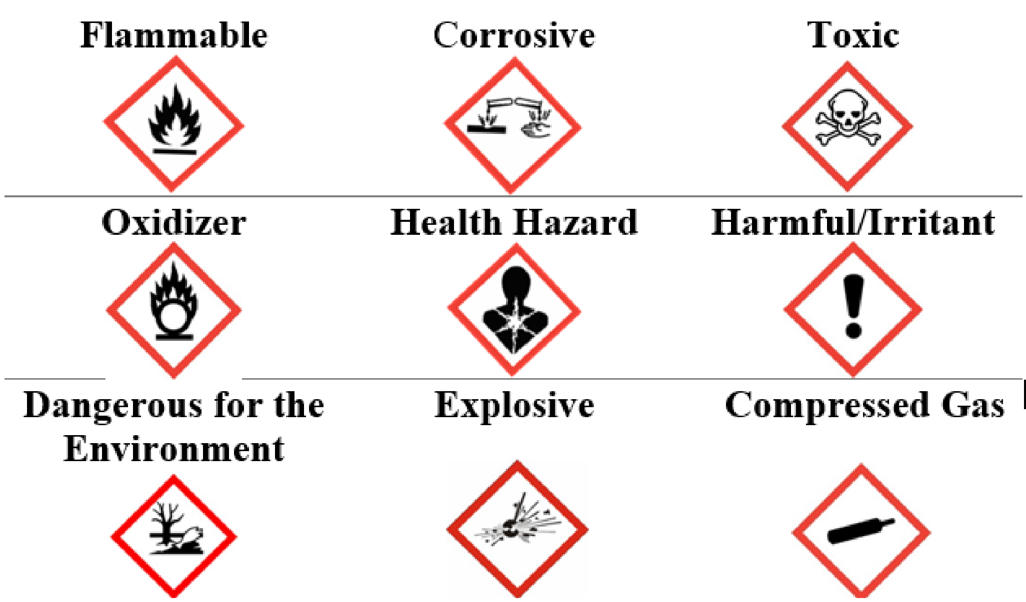
16. Other information including information on preparation and revision of the SDS

Labels, Signs and Other Forms of Warning

Labeling requirements for all hazardous substances are summarized as follows:

- Labels on incoming containers of hazardous chemicals shall not be removed or defaced until the container is completely empty
- All containers of hazardous materials must be labeled with the identity of the hazardous substance and all applicable hazard warning statements. If abbreviations are used, each room should have a posting listing the abbreviations used, along with the full chemical names. In either case, all containers not actively being used in transfer or a reaction, must be labeled.
- Labels must be legible, in English, and clearly displayed; Lewis structures alone are inadequate
- The label must contain all applicable hazard warning statements
- Newly synthesized compounds must be labeled with worker's information and chemical name or structure if known or at a minimum a chemical identification number derived from the employee's lab-book
- Non-original containers (e.g., smaller or temporary containers into which a material is transferred for use) must be labeled with the identity of the substance and appropriate hazard warnings
- Symbols and/or other languages may be provided for non-English speaking individuals
- Prepared mixtures and/or buffers must be labeled with the appropriate hazard warnings based on the knowledge of the chemical and physical properties of that substance
- Use the symbols in the Globally Harmonized System of Classification and Labeling of Chemicals

Globally Harmonized System (GHS)



Explosive– self-reactive, organic peroxides
Flammable– pyrophoric, self-heating, emits flammable gas, self-reactive, organic peroxides
Oxidizing – Oxidizers
Compressed Gas– gases under pressure
Harmful/Irritant– irritant (skin and eye), skin sensitizer, acute toxicity, narcotic effects, respiratory tract irritant, hazardous to ozone layer (non-mandatory)
Dangerous for the environment– aquatic toxicity
Health Hazard– carcinogen, mutagenicity, reproductive toxicity, respiratory sensitizer, target organ toxicity, aspiration toxicity
Corrosive– skin corrosion/burns, eye damage, corrosive to metals
Toxic– acute toxicity (fatal or toxic)

Information and Training

Training on specific workplace hazards must be provided at the time of initial assignment, whenever a new hazard is introduced into the workplace, and whenever lab personnel may be exposed to hazards in other work areas. General Hazard Communication Training is available through EH&S. Additional employee training is required whenever a new hazard is introduced into the work environment, and must be provided when receiving the SDS or other safety information and before the employee starts with said new hazard. All training must be in the appropriate language, educational level, and vocabulary for the personnel. Individuals must be given the opportunity to ask questions.

Personal Protective Equipment Assessment Tool (PPAT)

The Personal Protective Equipment Assessment Tool was developed to broadly identify activities involving chemical and other types of hazards and is an effective method of hazard communication. This document captures information on the specific type of hazard(s), the location of the hazard(s), the name of the PI/Laboratory Supervisor who oversees the facility and provides guidance for the proper exposure controls (Engineering, Administrative and Personal Protective Equipment (PPE)), that should be used by the laboratory personnel to protect themselves against these hazards. Once the PPE selection is made, the laboratory is required to conduct and document training for laboratory personnel on the use of PPE.
Additional Resources:

1. "Occupational Exposure to Hazardous Chemicals in Laboratories." California Code of Regulations Title 8, Section 5191.
2. Standard Operating Procedures (SOPs) for handling toxic chemicals (laboratory specific).
3. General information on the signs and symptoms associated with exposure to hazardous substances used in the laboratory or facility (laboratory specific SOPs or SDS)
    a. Identity labels, showing contents of containers (including waste receptacles) and associated hazards
    b. Label hazardous waste containers. See the EH&S Waste Management website for hazardous waste management information

    c. Warnings at areas or equipment where special or unusual hazards exist (e.g., particularly hazardous substances)
4. Procedures to follow in case of an emergency:
    a. Emergency telephone numbers of emergency personnel/facilities, supervisors, and laboratory workers
    b. Location signs for safety showers, eyewash stations, other safety and first aid equipment, exits and areas where food and beverage consumption and storage are permitted
    c. Emergency Procedure poster
    d. Report injury, illness, or safety concern online: https://www.chapman.edu/faculty-staff/risk-management/reporting.aspx

7.0 CLASSES OF HAZARDOUS CHEMICALS

Regulatory Requirements

Implementation of the necessary work practices, procedures, and policies outlined in this chapter is required by the following:

- Title 8, CCR, Section 5194, "Hazard Communication"
- Title 8, CCR, Section 5209, "Carcinogens"

Other applicable regulations include those promulgated by the U.S. Department of Labor including 29 CFR 1910.1450 "Occupational Exposure to Hazardous Chemicals in Laboratories" (the "Laboratory Standard").

Identification & Classification of Hazardous Chemicals

Chemicals can be divided into several different hazard classes. The hazard class will determine how a chemical should be stored and handled and what special equipment and procedures are needed to use them safely.

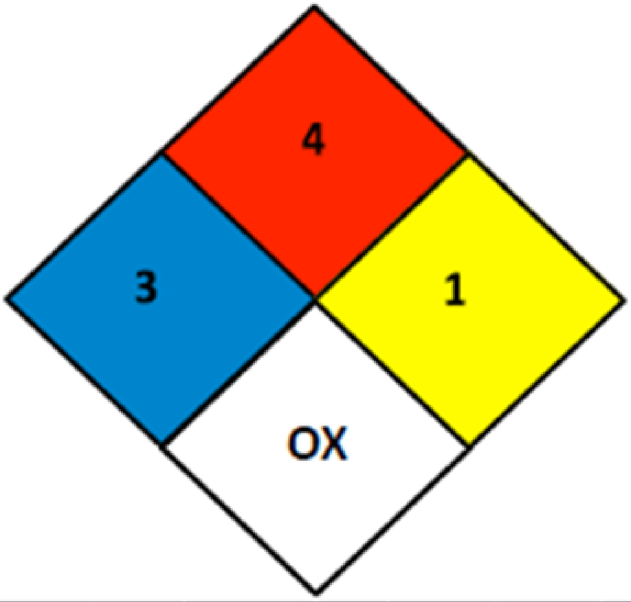
Each chemical container, whether supplied by a vendor or produced in the laboratory, must include labels that clearly identify the hazards associated with that chemical. In addition to specific chemical labels, hazard information for specific chemicals can be found by referencing the Safety Data Sheet (SDS) for that chemical.

It is essential that all laboratory workers understand the types of hazards, recognize the routes of exposure, and are familiar with the major hazard classes of chemicals. In many cases, the specific hazards associated with new compounds and mixtures will not be known, so it is recommended that all chemical compounds be treated as if they were potentially harmful and to use appropriate eye, inhalation and body protection equipment. Rooms containing hazardous chemicals are labeled with a door sign that gives an overview of the key chemical hazards contained within that room.

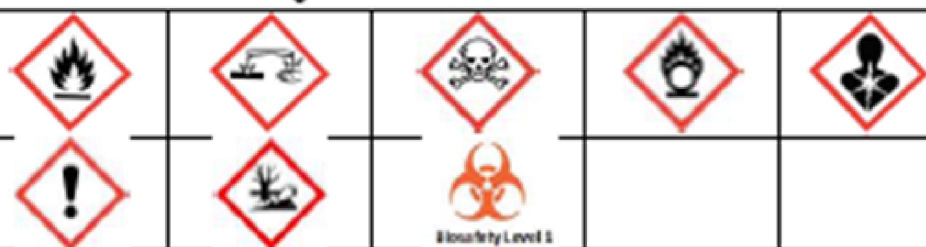
- Section 1 of the sign - lists the building and room number. Section 2 of the sign – identifies the National Fire Protection Agency (NFPA) hazard ratings and GHS specific hazards
- Section 3 of the sign - contains personal protection and physical hazards
- Section 4 of the sign – lists the name of the PI(s) and the emergency contact(s) information

Based on the hazards, the placard may contain the familiar NFPA four color, 0-4 number rating symbol that quickly supplies the hazard information broken down into four hazard classes, with 1 indicating a low level of hazard and 4 indicating a high hazard level. The four chemical hazard types correspond to the four color areas: red indicates a flammability hazard, yellow indicates a reactive hazard, blue indicates a health hazard and the white area is reserved for special hazards that are identified by hazard symbols or labels to indicate hazards such as radioactivity, biohazard, water reactive chemicals, etc. Each of these hazards has a different set of safety precautions associated with them. The figure below is an example of a Chapman placard along with an explanation of the NFPA Rating System.

Building: Keck Center for Science and Engineering, Schmid College of Science & Technology
Room: KCSE 161, General Biology Prep Lab



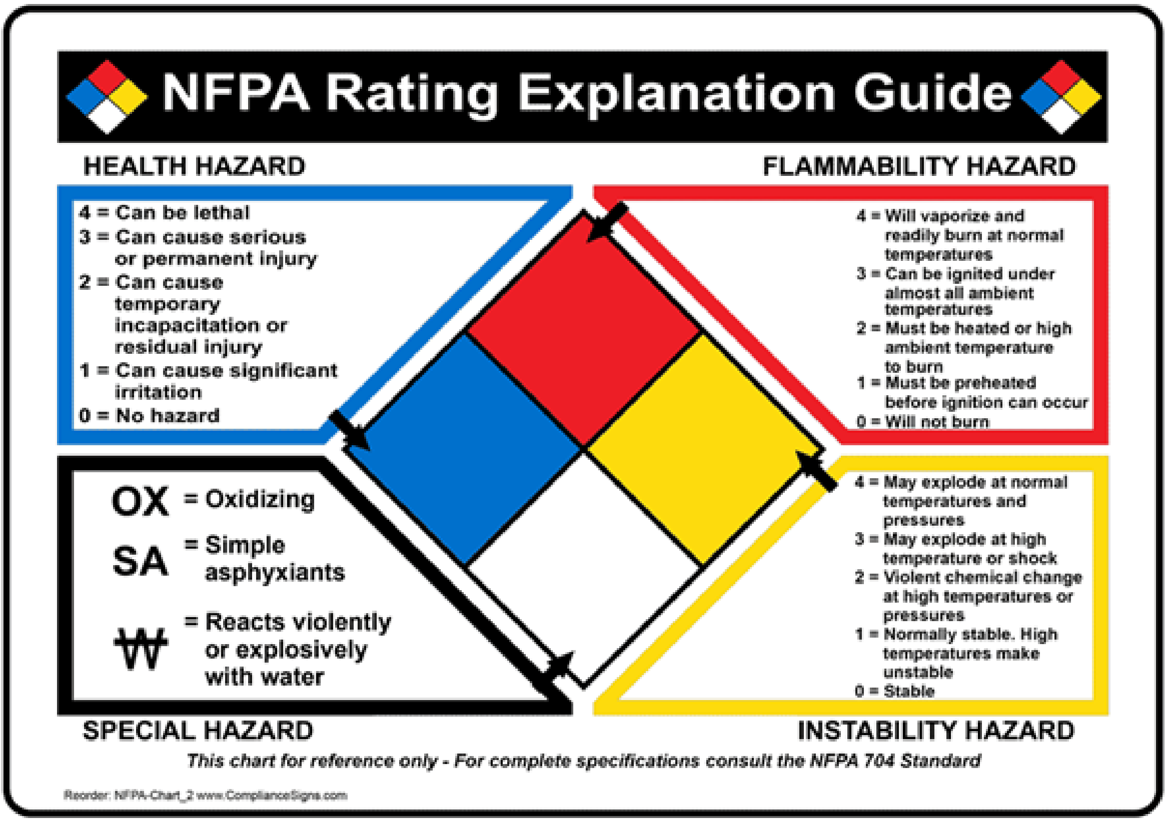
Authorized Personnel Only



In Case of Emergency
Call Public Safety
(714) 997-6763

Emergency Contact	Name	Office Location	Campus Phone	Emergency Phone
Principal Investigator				(714) 997-6763
Principal Investigator				
Principal Investigator				
Director of Laboratory Safety	Justin O'Neill	KCSE 147	(714)516-5625	(626)840-0398
Environmental Health and Safety Manager	Karen Swift	EHS General Office	(714)628-2888	(714)336-0030

Rev. 4/18/2018 EH&S



Flammability Hazards

A number of highly flammable substances are in common use in campus laboratories. Flammable liquids include those chemicals that have a flashpoint of less than 200 degrees Fahrenheit (93 degrees Celsius). These materials must be stored in self-closing flammable storage cabinets in aggregate quantities of 10 gallons or more per room. If less than 10 gallons, flammables can be stored in regular cabinets. No more than 60 gallons of flammable liquids may be stored inside of an approved flammable liquid storage cabinet.

Flame-resistant laboratory coats must be worn when working with large quantities (4 liters or more) of flammable materials and/or with procedures where a significant fire risk is present (e.g., when working with open flame or near ignition sources). These materials can constitute a significant immediate threat and should be treated with particular care, even though the use of these materials is fairly common in the laboratory setting. Particular attention should be given to preventing static electricity and sparks when handling flammable liquids by using electrical grounding and bonding techniques whenever possible.

Reactivity Hazards

Reactive and explosive substances are materials that decompose under conditions of mechanical shock, elevated temperature, or chemical action, and release large volumes of gases and heat. Some materials, such as peroxide formers, may not be explosive, but may form explosive substances over time. These substances pose an immediate potential hazard and procedures which use them must be carefully reviewed. These materials must also be stored in a separate flame-resistant storage cabinet or, in many cases, in a separate laboratory grade refrigerator or freezer that is designed for flammable/ reactive chemicals. Peroxide formers can only be stored in refrigerators when unopened. Once used, they have to be stored in a dry environment. Pyrophoric chemicals are a special classification of reactive materials that spontaneously combust when in contact with air and require laboratory-specific training and use of appropriate engineering controls and equipment such as glove boxes as one example. Flame resistant laboratory coats or other appropriate flame resistant protection must always be worn when working with pyrophoric chemicals.

Health Hazards

Cal/OSHA uses the following definition for health hazards:

- The term 'health hazard' includes chemicals which are carcinogens, toxic or highly toxic agents, reproductive toxins, irritants, corrosives, sensitizers, hepatotoxins, nephrotoxins, neurotoxins, agents which act on the hematopoietic systems, and agents which damage the lungs, skin, eyes, or mucous membranes.

The major classes of "hazardous" and "particularly hazardous substances" and their related health and safety risks detailed below:

Corrosive Substances

As a health hazard, corrosive substances cause destruction of, or alterations in, living tissue by chemical action at the site of contact.

Major classes of corrosive substances include:

- Strong acids – e.g., sulfuric, nitric, hydrochloric acids and hydrofluoric acids
- Strong bases – e.g., sodium hydroxide, potassium hydroxide and ammonium hydroxide
- Dehydrating agents – e.g., sulfuric acid, sodium hydroxide, phosphorus pentoxide and calcium oxide
- Oxidizing agents – e.g., hydrogen peroxide, chlorine and bromine.

Symptoms of exposure for inhalation include a burning sensation, coughing, wheezing, laryngitis, shortness of breath, nausea, and vomiting. For eyes, symptoms include pain, blood shot eyes, tearing, and blurring of vision. For skin, symptoms may include reddening, pain, inflammation, bleeding, blistering and burns. As a physical hazard, corrosive substances may corrode materials they come in contact with and may be highly reactive with other substances. It is important to review information regarding the materials they may corrode, and their reactivity with other substances, as well as information on health effects. In most cases, these materials should be segregated from other chemicals and require secondary containment when in storage.

Irritants

Irritants are defined as non-corrosive chemicals that cause reversible inflammatory effects on living tissue by chemical action at the site of contact. A wide variety of organic and inorganic compounds, including many chemicals that are in a powder or crystalline form, are irritants. The most common example of an irritant may be ordinary smoke which can irritate the nasal passages and respiratory system. Consequently, eye and skin contact with all laboratory chemicals should always be avoided. Symptoms of exposure can include reddening or discomfort of the skin and irritation to respiratory systems.

Sensitizer

A sensitizer (allergen) is a substance that causes exposed people to develop an allergic reaction in normal tissue after repeated exposure to the substance. Examples of sensitizers include diazomethane, chromium, nickel, formaldehyde, isocyanates, arylhydrazines, benzylic and allylic halides, and many phenol derivatives. Sensitizer exposure can lead to all of the symptoms associated with allergic reactions, or can increase an individual's existing allergies.

Hazardous Substances with Toxic Effects on Specific Organs

Substances included in this category include:

- Hepatotoxins – i.e., substances that produce liver damage, such as nitrosamines and carbon tetrachloride
- Nephrotoxins – i.e., agents causing damage to the kidneys, such as certain halogenated hydrocarbons
- Neurotoxins – i.e., substances which produce their primary toxic effects on the nervous system, such as mercury, acrylamide and carbon disulfide
- Agents which act on the hematopoietic system – e.g., carbon monoxide and cyanides which decrease hemoglobin function and deprive the body tissues of oxygen
- Agents which damage lung tissue – e.g., asbestos and silica. Symptoms of exposure to these materials vary. Personnel working with these materials should review the SDS for the specific material being used, take special note of the associated symptoms of exposure and contact EH&S for assistance

Symptoms of exposure to these materials vary. Personnel working with these materials should review the SDS for the specific material being used, take special note of the associated symptoms of exposure and contact EH&S for assistance.

Particularly Hazardous Substances

OSHA recognizes that some classes of chemical substances pose a greater health and safety risk than others. To differentiate this additional risk characteristic, OSHA identifies two categories of hazardous chemicals:

1. Hazardous Chemicals
2. Particularly hazardous substances

Substances that pose such significant threats to human health are classified as "particularly hazardous substances" (PHSs). The OSHA Laboratory Standard and Cal/OSHA regulation require that special provisions be established to prevent the harmful exposure of researchers to PHSs, including the establishment of designated areas for their use.

- Use of containment devices such as fume hoods or glove boxes
- Procedures for safe removal of contaminated waste
- Decontamination procedures

Particularly hazardous substances are divided into three primary types:

1. Acute Toxic Chemicals
2. Reproductive Toxins
3. Carcinogens

Acute Toxic Chemicals

Substances that have a high degree of acute toxicity are interpreted by OSHA as being substances that "may be fatal or cause damage to target organs as the result of a single exposure or exposures of short duration." These chemicals, associated chemical waste, and storage containers must be handled with care to prevent cross contamination of work areas and unexpected contact. These chemicals must be labeled as "Toxic." Empty containers of these substances must be packaged and disposed of as hazardous waste without rinsing trace amounts into the sewer system.

Reproductive Toxins

Reproductive toxins include any chemical that may affect the reproductive capabilities, by methods such as chromosomal damage (mutations) and effects on fetuses (teratogenesis).

Reproductive toxins can affect the reproductive health of both men and women if proper procedures and controls are not used. For women, exposure to reproductive toxins during pregnancy can cause adverse effects on the fetus; these effects include embryolethality (death of the fertilized egg, embryo or fetus), malformations (teratogenic effects), and postnatal functional defects. For men, exposure can lead to sterility.

Examples of embryotoxins include thalidomide and certain antibiotics such as tetracycline. Women of childbearing potential should note that embryotoxins have the greatest impact during the first trimester of pregnancy. Because a woman often does not know that she is pregnant during this period of high susceptibility, special caution is advised when working with all chemicals, especially those rapidly absorbed through the skin (e.g., formamide). Pregnant women and women intending to become pregnant should consult with their laboratory supervisor and EH&S before working with substances that are suspected to be reproductive toxins.

Carcinogens

Carcinogens are chemical or physical agents that cause cancer. Generally they are chronically toxic substances; that is, they cause damage after repeated or long-duration exposure, and their effects may only become evident after a long latency period. Chronic toxins are particularly insidious because they may have no immediately apparent harmful effects. These materials are separated into two classes:

1. Select Carcinogens
2. Regulated Carcinogens

Select carcinogens are materials which have met certain criteria established by the National Toxicology Program (NTP) or the International Agency for Research on Cancer (IARC) regarding the risk of cancer via certain exposure routes. It is important to recognize that some substances involved in research laboratories are new compounds and have not been subjected to testing for carcinogenicity. The following references are used to determine which substances are select carcinogens by Cal/OSHA's classification:

- OSHA Carcinogen List
- Annual Report on Carcinogens published by the National Toxicology Program (NTP), including all the substances listed as "known to be carcinogens" and some substances listed as "reasonably anticipated to be carcinogens" based on the below standard
- IARC Monographs on the Identification of Carcinogenic Hazards to Humans, including all of Group 1 "carcinogen to humans," and some in Group 2A "probably carcinogenic to humans" or 2B, "possibly carcinogenic to humans" based on the below standard
- For substances listed in either Group 2A or 2B by IARC or under the category "reasonably anticipated to be carcinogens" by NTP, to be considered a "select carcinogen" by Cal/OSHA, it must also cause statistically significant tumor incidence in experimental animals in accordance with any of the following criteria:
    - 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;
    - 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

Regulated Carcinogens fall into a higher hazard class and have extensive additional requirements associated with them. The use of these agents may require personal exposure sampling based on usage. When working with Regulated Carcinogens, it is particularly important to review and effectively apply engineering and administrative safety controls as the regulatory requirements for laboratories that may exceed long term (8 hour) or short term (15 minutes) threshold values for these chemicals are very extensive.

Chemicals Known to the State of California to Cause Cancer or Reproductive Toxicity

The Safe Drinking Water and Toxic Enforcement Act of 1986, also known as Proposition 65, requires the State to publish a list of chemicals known to cause cancer or reproductive toxicity, known as "The Proposition 65 List." The list is updated regularly and reviewed by two committees that are a part of the Office of Environmental Health Hazard Assessment's Science Advisory Board. The two committees are the Carcinogen Identification Committee (CIC) and Developmental and Reproductive Toxicant (DART) Identification Committee.

Nanomaterials

The increasing use of nanomaterials in research labs warrants consideration of the hazards they may pose. As is the case with many new technologies, the health effects of nanomaterials have not been thoroughly investigated. Consequently, the uncertainty surrounding the toxicity of nanomaterials merits a cautious approach when working with them.

Nanomaterials include any materials or particles that have an external dimension in the nanoscale (~1- 100nm). Nanomaterials are both naturally occurring in the environment and intentionally produced. Intentionally produced nanomaterials are referred to as Engineered Nanomaterials (ENMs). Materials whose properties do not differ significantly between their nanoscale and larger forms are generally excluded from ENMs. The most common types of

Table 3.1 Types of Nanomaterials

Carbon Based	Buckyballs or Fullerenes, Carbon Nanotubes*, Dendrimers *Often includes functional groups like *PEG (polyethylene glycol), Pyrrolidine, N,N-dimethylethylenediamine, imidazole*
Metals and Metal Oxides	Titantium Dioxide (Titania)**, Zinc Oxide, Cerium Oxide (Ceria), Aluminum oxide, Iron oxide, Silver, Gold, and Zero Valent Iron (ZVI) nanoparticles
Quantum Dots	ZnSe, ZnS, ZnTe, CdS, CdTe, GaAs, AlGaAs, PbSe, PbS, InP *Includes crystalline nanoparticle that exhibits size-dependent properties due to quantum confinement effects on the electronic states (ISO/TS 27687:2008).*

ENMs are carbon based materials such as nanotubes, metals and metal oxides such as silver and zinc oxide, and quantum dots made of compounds such as zinc selenide (Table 3.1).

Nanomaterials can be categorized by the potential risk of exposure they pose to personnel based on the physical state of the materials and the conditions in which they are used (Table 3.2). In general, the risk of exposure is lowest when nanomaterials are bound in a solid matrix with little potential to create airborne dust or when in a non-volatile liquid suspension. The risk of exposure increases when nanomaterials are used as fine powders or are suspended in volatile solvents or gases. The parent compound of the nanomaterial should also be taken into consideration when evaluating the potential hazards associated with exposure (e.g., a highly toxic compound such as cadmium should be anticipated to be at least as toxic and possibly more toxic when used as a nanomaterial).

A detailed Standard Operating Procedure (SOP) for working with nanomaterials should be written to provide guidance on appropriate work practices, engineering controls, personal protective equipment (PPE), and waste disposal practices depending on the risk level of a particular nanomaterial or process involving a nanomaterial.

For further information, see the California Nanosafety Consortium of Higher Education’s “Nanotoolkit: Working Safely with Engineered Nanomaterials in Academic Research Setting”, the National Institute of Occupational Safety & Health’s (NIOSH) “General Safe Practices for Working with Engineered Nanomaterials in Research Laboratories, and the NIOSH “Current

Strategies for Engineering Controls in Nanomaterial Production and Downstream Handling Processes."

Table 3.2 Nanomaterial Risk Categories

Category 1 Lower Exposure Potential	**Material State** • No potential for airborne release (when handling) • Solid: Bound in a substrate or matrix • Liquid: Water-based liquid suspensions or gels • Gas: No potential for release into air (when handling) **Type of Use** • No thermal or mechanical stress	• Non-destructive handling of solid engineered nanoparticles permanently bonded to a substrate
Category 2 Moderate Exposure Potential	**Material State** • Moderate potential for airborne release (when handling) • Solid: Powders or Pellets • Liquid: Solvent-based liquid suspensions or gels • Gas: Potential for release into air (when handling) **Type of Use** Thermal or mechanical stress induced	• Pouring, heating, or mixing liquid suspensions (e.g., stirring or pipetting), or operations with high degree of agitation involved (e.g. sonication) • Weighing or transferring powders or pellets • Changing bedding out of laboratory animal cages.
Category 3 Higher Exposure Potential	**Material State** • High potential for airborne release (when handling) • Solid: Powders or Pellets with extreme potential for release into air • Gas: Suspended in gas	• Generating or manipulating nanomaterials in gas phase or in aerosol form • Furnace operations • Cleaning reactors • Changing filter elements • Cleaning dust collection systems used to capture nanomaterials • High speed abrading/grinding nanocomposite materials

8.0 REDUCING EXPOSURES TO HAZARDOUS CHEMICALS

Hazardous chemicals require a carefully considered, multi-tiered approach to ensure safety. There are four primary routes of exposure for chemicals which have associated health hazards:

Eye/Skin Contact

- Immediately go to the emergency shower/eye wash facility and following further instructions or refer to the "Emergency Eyewash and Shower Equipment SOP and Testing Guide/Instructions
- Flush affected body area with water for at least 15 minutes or more
- Do not use neutralizing chemicals, creams, abrasives, or lotions
- If the eyes have been contaminated, forcibly hold them open and flush for least 15 minutes or more
- Resume flushing area with water if pain continues
- Contact Chapman University Public Safety for all emergencies and EH&S to report the incident

Inhalation

- Move exposed person to fresh air if safe to do so
- If the victim is not breathing, contact Public Safety and perform CPR (if certified) until medical assistance arrives. Be careful to avoid exposure to chemical poisoning via mouth-to-mouth resuscitation. If available, use a mouth-to-mask resuscitator

Ingestion

- Contact Public Safety and request medical assistance
- If possible, determine what material was ingested by victim
- If victim begins to vomit, turn head or entire body to one side to avoid choking
- Do not induce the victim to vomit or drink any beverage unless instructed to by qualified medical personnel
- If victim stops breathing, see Inhalation, step 2

Injection

- Contact the Chapman University Public Safety and request medical assistance

The most likely route of exposure in the laboratory is by inhalation. Many hazardous chemicals may affect people through more than one of these exposure modes, so it is critical that protective measures are in place for each of these uptake mechanisms

Safety Controls

Safety controls are divided into three main classifications:

1. Engineering Controls
2. Administrative Controls
3. Personal Protective Equipment (PPE)

Elements of these three classes are used in a layered approach to create a safe working environment. The principles of each of these elements are detailed below.

Engineering Controls

Engineering controls include all “built in” safety systems. These controls offer the first line of protection and are highly effective in that they generally require minimal special procedures or actions on the part of the user except in emergency situations. A fundamental and very common example is the laboratory fume hood which is very effective at containing chemical hazards and protecting users from inhalation hazards. Other examples of engineering controls include general room ventilation, flammable material storage units, and secondary containment.

General Laboratory Ventilation

All laboratory rooms in which hazardous materials are used must have fresh air ventilation with 100% of the exhaust venting to the outside; laboratory rooms should not be part of recycled air systems. In cases where this is not feasible, a formal hazard evaluation will be made by EH&S to determine what work can be done in the space and under what special conditions or limitations. Laboratory rooms should be kept at negative pressure compared to public areas to prevent the spread of hazardous vapors.

Fume Hoods

Fume hoods are the most commonly used local exhaust system on campus. Other methods include vented enclosures for large pieces of equipment or chemical storage, and portable exhaust systems for capturing contaminants near the point of release. Some systems are equipped with air cleaning devices (HEPA filters or carbon absorbers). A properly designed and operated fume hood reduces exposure to hazardous fumes, vapors, gases and dusts.

It is advisable to use a laboratory hood when working with all hazardous substances. In addition, a laboratory hood or other suitable containment device must be used for all work with "particularly hazardous substances." A properly operating and correctly used laboratory hood can reduce or eliminate volatile liquids, dusts and mists. It also serves to shield the worker from a runaway reaction. Fume hoods are evaluated for operation and certified by an outside contractor under EH&S’s oversite on an annual basis. These annual evaluations check the fume hood air flow velocity to ensure that the unit will contain hazardous vapors. Data on annual fume hood monitoring will be maintained by EH&S. Each fume hood should have a current calibration sticker and a marker indicating the highest sash height to be used when working with hazardous materials. Contact EH&S for a hood evaluation if these labels are missing.

Each fume hood must be equipped with at least one type of continuous quantitative monitoring device designed to provide the user with current information on the operational status of the hood. Many hoods also have motion sensors to determine when they are not in active use. These sensors will reduce the fume hood's air flow as part of the campus' energy savings effort. When hazardous materials are in a fume hood, but it is not under active use (e.g., during an unattended reaction or experiment), the sash should be closed. Fume hoods should not be used for storage of hazardous materials.

Routine maintenance and repairs of fume hoods are conducted by Facilities Services. Hood users may requests for hood repair directly to EH&S. Hood users should remove and properly store excess items, and clean the hood surface prior to repairing or providing maintenance to the hood. EH&S or the user may initiate maintenance as well as coordinate with Facilities Services to ensure that it is completed. Upon reported completion by Facilities Services, EH&S will re-inspect the fume hood following maintenance or repairs.

General Rules for Fume Hood Use:

- Fume hoods should not be used for work involving hazardous substances unless they have a certification label that confirms certification has occurred within the past year
- Verify that the exhaust system is operating before working in the hood. Hold a strip of paper, tissue, or ribbon at the face of the hood to indicate the direction of air flow. If the hood is not working, alert others, post/label as "Do Not Use". Contact EH&S and place a work order with Facilities Management;
- Keep the sash between 12 and 16 inches (30-41 cm) when setting up, running, or dismantling an experiment. However, if possible, work with the hood sash in the lowest practical position. The sash acts as a physical barrier in the event of an accident. Keep the sash closed when not conducting work in the hood
- Set up equipment at least six 6 inches (15 cm) from the sash within the fume hood
- Never put your head inside a laboratory hood containing hazardous materials. The plane of the sash is the barrier between contaminated and uncontaminated air
- Elevate hot plates, ovens, and other large objects 1 or 2 inches (3-5 cm) above the work surface to allow air to flow underneath them
- Containers placed in fume hoods to collect hazardous liquid waste must be capped after each use
- Since perchloric acid can only be used in fume hoods designed for its use, contact EH&S prior to any work
- If a fire occurs in the fume hood quickly shut the sash if it is safe to do so and contact Public Safety. In the case of work done at the Rinker Health Sciences Campus, notify City of Irvine Police Department through the 911 service
- **DO NOT** overcrowd or clutter the fume hood. Overcrowding creates vortices and dead spots. Vortices may cause hazardous material to flow back out of the fume hood thus exposing the employee; dead spots may allow ignitable concentrations of flammable and combustible materials to accumulate;
- **DO NOT** erect shelves in a fume hood for chemical or equipment storage;

- **DO NOT** place electrical receptacles, power strips, or other spark producing sources inside the hood;
- **DO NOT** make any modifications to hoods, duct work, or the exhaust system without first contacting EH&S
- **DO NOT** store chemicals inside the fume hood. Fume hoods should contain only working volumes of chemicals;
- **DO NOT** use fume hoods to vent or dispose of hazardous materials through air dilution. This is in violation of the EPA Clean Air Act and South Coast Air Quality Management District.

Laboratory fume hoods are one of the most important pieces of equipment used to protect laboratory and other workers from exposure to hazardous chemicals. Chemical fume hoods should be inspected upon installation, renovation, when a deficiency is reported, or a change has been made to the operating characteristics of the hood. Since fume hoods used for regulated carcinogens have additional requirements, such as increased face velocity, contact the EH&S if the intended use changes.

Fume Hood Inspection

Physical Inspection

Evaluate the physical condition of the hood and the materials being used in the hood. This includes checking for:

- Improper storage of materials inside the fume hood
- Use of proper materials
- General hood cleanliness
- Physical damage to the fume hood (e.g. broken or cracked sash)
- Fully functioning lighting, fume hood indicator, airflow monitor, and alarm

Hood Performance Inspection

- An outside contractor certifies the fume hoods annually. Verify the hood is operational prior to use
- Average face velocity and set minimum face velocity, which is used to determine the rating of the hood and what the hood can be used for
- Noise generated by the fume hood
- The average face velocity must be between 100 and 125 feet per minute (fpm) for normal use; between 125 and 150 fpm for work involving, carcinogenic or highly toxic materials. If these specifications cannot be met, Chapman University Facilities Management will adjust the air flow.

Immediately report any fume hood that is not working properly to EH&S and Facilities Management. Facilities Management will repair the hood and it will be re-certified to ensure proper operation

Glove Boxes and Ventilation Devices

In addition to fume hoods, some laboratories use contained glove box units for working with reactive chemicals under an inert environment, working with very toxic substances in a completely closed system, or for creating a stable, breeze free, environment for weighing hazardous or reactive materials. These units can be very effective because they offer complete containment.

Another type of ventilation device is the elephant trunk, or snorkel, which is connected to the exhaust system. This device is effective for capturing discharges from instruments such as gas chromatographs. The intake of the snorkel must be placed very close to the source to be effective.

Other Engineering Controls

In addition to the elements listed above, consideration must be given to providing sufficient engineering controls for the storage and handling of hazardous materials. No more than 10 gallons (38 liters) of flammable chemicals may be stored outside of an approved flammable storage cabinet. For refrigerated or frozen storage, flammable and explosive materials must be kept in refrigeration units specifically designed for storing these materials. Generally these units do not have internal lights or electronic systems that could spark and trigger an ignition; additionally, the cooling elements are external to the unit. These units should be labeled with a rating from Underwriters Laboratory (UL) or other certifying organization. Secondary containment must be provided for corrosive and reactive chemicals and is recommended for all other hazardous chemicals. Secondary containment should be made of chemically resistant materials and should be sufficient to hold at least 110% the volume of at least the largest single bottle stored in the container. Laboratories that use hazardous materials must contain a sink, kept clear for hand washing to remove any final residual contamination. Hand washing is recommended whenever a staff member who has been working with hazardous materials plans to exit the laboratory or work on a project that does not involve hazardous materials.

Administrative Controls

The next layer of safety controls is Administrative Controls. These controls consist of policies and procedures; they are not generally as reliable as engineering controls in that the user has to carefully follow the appropriate procedures and must be fully trained and aware in order to do so.

Laboratory groups should also review their operations to minimize the amounts of hazardous substances in use or to replace them with less hazardous alternatives. Attention must also be paid to the appropriate segregation of incompatible materials. Follow the below guidelines on best laboratory practices

Equipment Storage and Handling:

- Always plan experiments with safety as the first priority;
- Ensure that proper safety equipment is close and accessible (e.g. fire extinguisher, spill kits, safety showers, etc.)

- Never leave equipment running unattended or overnight without having some fail-safe mechanism to prevent disaster
- All gas cylinders must be secured at all times
- When setting up lattices, ensure that mounts to the lab bench are secured properly;
- Glass reaction vessels attached to lattices should be equipped with protective pans to contain spillage in the event the vessel breaks
- High vacuum systems should be assembled with due care. Sample vessels or ampoules should be wrapped with cloth or electrical tape in the event of an implosion/explosion. Blast shields or windows constructed of polycarbonate or Plexiglas should be mounted directly in front of the sample vessel being used
- Store laboratory glassware with care to avoid damage. Use extra care with Dewar flasks and other evacuated glass apparatus; shield or wrap them to contain chemicals and fragments should implosion occur
- Equipment and/or chemicals stored on open shelves should have Plexiglas (or other suitable alternative) lips to prevent "walk-off" during an earthquake or spillage from accidental contact when removing other containers
- Ensure that vacuum pumps are equipped with proper and functional guards for safe operation. Guards should be placed over belts
- Do not use damaged glassware or other equipment

Laboratory Operations:

- Inform co-workers of hazardous work being conducted
- Seek information and advice about hazards, plan appropriate protective procedures, and plan positioning of equipment before beginning any new operation
- Confine long hair and loose clothing
- Coordinate with research staff to ensure active surveillance of employees working alone in the laboratory after business hours
- Place warning labels to indicate hot surfaces
- If unattended operations are unavoidable, and have been approved by the PI/Laboratory Supervisor, place an appropriate sign on the door, leave lights on, and provide for containment of toxic substances in the event of failure of a utility service (such as cooling water)
- Be alert to unsafe conditions and ensure that they are corrected when detected
- Use non-mercury thermometers for laboratory use
- For work involving radioactive, carcinogenic, or highly toxic materials, designate a specific area and label accordingly. Obtain approval from EH&S before conducting such hazardous work.
- **NEVER** throw or dump chemicals into the trash or sink
- Research staff and students should never work alone on procedures involving hazardous chemicals, biological agents, or other physical hazards

- Do not engage in distracting behavior such as practical jokes in the laboratory. This type of conduct may confuse, startle, or distract another worker
- Report all safety hazards to the supervisor
- Wash areas of exposed skin well before leaving laboratory

Food/ Drink:

- Do not eat, drink, smoke, chew gum, or apply cosmetics in areas where laboratory chemicals are present; wash hands before conducting these activities
- Do not store, handle, or consume food or beverages in storage areas, refrigerators, glassware or utensils which are also used for laboratory operations
- When food is stored and used for laboratory use, mark containers as experimental use only and not for human consumption.

Standard Operating Procedures

Standard operating procedures (SOPs) that are relevant to safety and health considerations must be developed and followed when laboratory work involves the use of hazardous chemicals (CCR, Title 8, Section 5191 (e)(3)(A)), especially for "particularly hazardous substances" (PHS) and any hazardous materials with a GHS hazard of 1 SOPs are written instructions that detail the steps that will be performed during a given experimental procedure and include information about potential hazards and how these hazards will be mitigated. SOPs should be written by laboratory personnel who are most knowledgeable and involved with the experimental process. The development and implementation of SOPs is a core component of promoting a strong safety culture in the laboratory and helps ensure a safe work environment.

While general guidance regarding laboratory work with chemicals is contained in this plan, Faculty/Other Laboratory Supervisors are required to develop and implement laboratory-specific SOPs for certain hazardous chemicals that are used in their laboratories. These SOPs must be submitted by the Primary Investigator and reviewed by EH&S (depending on the experiment) prior to implementation. For certain hazardous chemicals or specialized practices, consideration must be given to whether additional consultation with safety professionals is warranted or required.

Circumstances requiring prior approval from the PI/Laboratory Supervisor must also be addressed in laboratory specific SOPs. These circumstances are based on the inherent hazards of the material being used, the hazards associated with the experimental process, the experience level of the worker, and the scale of the experiment. Some examples of circumstances that may require prior approval include working alone in a laboratory, unattended or overnight operations, the use of extremely reactive chemicals (e.g., pyrophorics, water reactive chemicals), or the use of carcinogens. The use of highly toxic, toxic or corrosive gases must be approved by EH&S prior to use.

EH&S is available to assist with the development of SOPs. SOPs must be approved prior to initiating any experiments with hazardous chemicals with GHS hazard rating of 1 or particularly hazardous substances and are to be filed and maintained in the Laboratory Safety Manual where they are available to all laboratory personnel.

When drafting an SOP, consider the type and quantity of the chemical being used, along with the frequency of use. Reference the Safety Data Sheet (SDS) for each hazardous chemical. The SDS lists important information that will need to be considered, such as exposure limits, type of toxicity, warning properties, and symptoms of exposure. If a new chemical will be produced during the experiment, an SDS will not necessarily be available. In these cases, the toxicity is unknown and it must be assumed that the substance is particularly hazardous, as a mixture of chemicals will generally be more toxic than its most toxic component.

All laboratory personnel must be trained on lab-specific procedures and associated hazards by the Principal Investigator, Laboratory Manager, and Supervisor or designated person. Training is also required when procedures are revised. A record of the training must be available for inspection.

Personal Protective Equipment

Personal protective equipment (PPE) serves as a researcher's last line of defense against chemical exposures and is required by everyone entering a laboratory containing hazardous chemicals.

Basic PPE requirements and best practices, which include but are not limited to:

- Full length pants and close-toed shoes, or equivalent
- Protective gloves, laboratory coats, & eye protection when working with, or adjacent to, hazardous chemicals
- Flame resistant laboratory coats for high hazard materials, pyrophorics, and ≥4 liters of flammables
- Remove laboratory coats or gloves immediately on significant contamination, as well as before leaving the laboratory
- Avoid use of contact lenses in the laboratory unless necessary. If they are used, inform supervisor so special precautions can be taken
- Use any other protective and emergency apparel and equipment as appropriate. Be aware of the locations of first aid kits and emergency eyewash and shower station

The primary goal of basic PPE is to mitigate the hazard associated with exposure to hazardous substances. In some cases, additional, or more protective, equipment must be used. If a project involves a chemical splash hazard, chemical goggles are required; face shields may also be required when working with chemicals that may cause immediate skin damage. Safety goggles differ from safety glasses in that they form a seal with the face, which completely isolates the eyes from the hazard. If a significant splash hazard exists, heavy gloves, protective aprons and sleeves may also be needed. Gloves should only be used under the specific condition for which they are designed, as no glove is impervious to all chemicals. It is also important to note that gloves degrade over time, so they should be inspected before each use and replaced as necessary to ensure adequate protection.

EH&S requires each laboratory to complete a Personal Protective Equipment Assessment Tool prior to beginning work and to provide annual updates thereafter. PPE can be selected based on this hazard assessment. Access the online Personal Protective Equipment Assessment Tool through https://www.chapman.edu/faculty-staff/environmental/_files/personal-protective-equipment-and-assessment-tool-d.pdf.

How to Use and Maintain PPE

Personal protective equipment should be kept clean and stored in an area where it will not become contaminated. Personal protective equipment should be inspected prior to use to ensure it is in good condition. It should fit properly and be worn properly. If it becomes contaminated or damaged, it should be cleaned or repaired when possible, or discarded and replaced.

Contaminated Clothing/PPE

In cases where spills or splashes of hazardous chemicals on clothing or PPE occur, the clothing/PPE should immediately be removed and placed in a closed container that prevents release of the chemical. Heavily contaminated clothing/PPE resulting from an accidental spill should be disposed of as hazardous waste. Lightly contaminated laboratory coats should be cleaned and properly laundered, as appropriate. Laboratory personnel should never take contaminated items home for cleaning or laundering. Persons or companies hired to clean contaminated items should be provided with hazard communication and personal protective equipment.

Respiratory Protection

Typically, respiratory protection is not needed in a laboratory. Under most circumstances, safe work practices, small scale usage, and engineering controls (fume hoods, biosafety cabinets, and general ventilation) adequately protect laboratory workers from chemical and biological hazards. Under certain circumstances, however, respiratory protection may be needed. These can include:

- Performance of an unusual operation that cannot be conducted under the fume hood or biosafety cabinet
- When weighing powdered chemicals or microbiological media outside a glove box or other protective enclosure. Disposable filtering face-piece respirators are generally recommended for nuisance dusts. If the chemicals are toxic, contact EH&S for additional evaluation
- When exposure monitoring indicates that exposures exist that cannot be controlled by engineering or administrative controls
- As required by a specific laboratory protocol or as defined by applicable regulations

Because there are numerous types of respirators available, and each has specific limitations and applications, respirator selection and use requires pre-approval by EH&S. For either required or voluntary use of a respirator, the employee must contact the EH&S department, who will contact the worker to evaluate the potential exposure. The review will include an evaluation of the work area and activities for the following:

- Provision of additional ventilation controls or enclosure of the airborne hazard
- Substitution with a less hazardous substance
- Qualitative or quantitative exposure assessment
- Respirator usage

Processes with potential airborne hazards that cannot be eliminated by engineering or administrative controls will not be authorized by EH&S until affected workers can be incorporated into Chapman's Respiratory Protection Program.

Because wearing respiratory equipment places a physical burden on the user, laboratory workers must be medically evaluated prior to wearing respiratory equipment. Certain individuals (e.g., persons with severe asthma, heart conditions, or claustrophobia) may not be medically qualified to wear a respirator. Upon enrollment in Respirator Training and Fit Testing, the employee will be sent the appropriate medical questionnaire. The completed medical questionnaire will be evaluated by a licensed health care professional before the employee proceeds with the training. NOTE: This medical questionnaire is confidential. The employee will be provided additional information on who to contact for follow up questions. After successful completion of the medical evaluation, the employee will be trained and fit tested by EH&S. Training topics include:

- Why the respirator is necessary and how improper fit, usage, or maintenance can compromise the protective effect of the respirator
- What the limitations and capabilities of the respirator are
- How to use the respirator effectively in emergency situations, including situations in which the respirator malfunctions
- How to inspect, put on and remove, use and check the seals of the respirator
- What the procedures are for maintenance and storage of the respirator
- How to recognize medical signs and symptoms that may limit or prevent the effective use of respirators
- The general requirements of the Respiratory Protection Program

Finally, a qualitative fit test for N95 use is conducted by EH&S. Any quantitative fit test will be conducted by an outside occupational health center for each respirator user. The fit test ensures a proper face to face piece seal for each individual and his/her mask. Fit testing is done in accordance with Cal/OSHA regulation Title 8, CCR, Section 5144 "Respiratory Protection."

An annual refresher is required for the medical evaluation, respirator training, and fit testing. In addition to the annual training refresher, a more frequent re-training, fit testing or medical evaluation must be performed when any of the following occur:

- Changes in the workplace or the type of respirator render previous training obsolete
- Inadequacies in the employee's knowledge or use of the respirator indicate that the employee has not retained the requisite understanding or skill
- Any other situation arises in which reevaluation appears necessary to ensure safe respirator use
- Facial scarring, dental changes, cosmetic surgery, or an obvious change in body weight
- An employee reports medical signs or symptoms related to their ability to use a respirator

9.0 CHEMICAL EXPOSURE

Regulatory Requirements

All Chapman personnel require protection from exposure to hazardous chemicals above Permissible Exposure Limits (PELs), Short Term Exposure Limits (STELs) and Ceiling concentrations. The profession with expertise in exposure assessment monitoring is Industrial Hygiene. At Chapman, the person supervising, directing or evaluating the exposure assessment monitoring must be competent in the practice of industrial hygiene. EH&S contracts personnel with this expertise. General questions regarding exposure assessment or can be directed to EH&S.

Minimizing an exposure may be accomplished using a combination of engineering controls, administrative controls and personal protective equipment, listed in order of priority. Assessing exposure to hazardous chemicals may be accomplished through a number of methods performed by EH&S, including employee interviews, visual observation of chemical use, evaluation of engineering controls, use of direct reading instrumentation, or the collection of analytical samples from the employee's breathing zone. Personal exposure assessment will be performed under either of the following situations:

- Based on chemical inventories, review of Standard Operating Procedures (SOPs), types of engineering controls present, laboratory inspection results and/or review of the annual Chapman Personal Protective Equipment Assessment Tool, EH&S determines whether an exposure assessment is warranted; or
- User of a hazardous chemical has concern or reason to believe exposure is not minimized or eliminated through use of engineering controls or administrative practices . The user should then inform his or her PI/Laboratory Supervisor, who will in turn contact the EH&S. EH&S will then determine the best course of action in assessing exposure, including visual assessment, air monitoring, medical evaluation, examination, or medical surveillance

In event of any serious injury or exposure, including chemical splash involving dermal or eye contact, immediately call 911 at the Rinker campus and extension 6763 (from an outside line: (714) 997-6963) and obtain medical treatment immediately. At the Orange campus call Public Safety. Do not wait for an exposure assessment to be performed before seeking medical care.

Exposure Assessment Protocol

EH&S conducts exposure assessments for members of the campus community. Exposure assessments may be performed for hazardous chemicals, as well as for physical hazards including noise and heat stress to determine if exposures are within PELs or other appropriate exposure limits that are considered safe for routine occupational exposure. The costs of exposure monitoring are the responsibility of the lab, department and organization in which the personnel is employed. General protocol in conducting an exposure assessment may include any of the following:

- Worker interviews
- Visual observation of chemical usage and/or laboratory operations
- Evaluation of simultaneous exposure to multiple chemicals
- Evaluation of potential for absorption through the sin, mucus membranes or eyes
- Evaluating existing engineering controls (such as measuring face velocity of a fume hood)

If exposure monitoring determines an employee exposure to be over the action level (or the PEL) for a hazard for which OSHA has developed a specific standard (e.g., lead), the medical surveillance provisions of that standard shall be followed. It is the responsibility of the PI/Laboratory Supervisor to ensure that any necessary medical surveillance requirements are met. When necessary, EH&S will make recommendations regarding adjustments to engineering controls or administrative procedures to maintain exposure below any applicable PEL. Where the use of respirators is necessary to maintain exposure below permissible exposure limits, Chapman will assist with recommending respiratory equipment and will provide training. Respirators will be selected and used in accordance with the requirements of CCR Title 8 Section 5144 “Respiratory Protection” and the University’s Respiratory Protection Program.

In assessing exposure to hazardous chemicals for which Cal/OSHA has not published a PEL, STEL or Ceiling exposure, EH&S defers to the Threshold Limit Values (TLVs) established by the American Conference of Governmental Industrial Hygienists (ACGIH) or the Recommended Exposure Limits (RELs) established by the National Institute of Occupational Safety & Health (NIOSH). Please contact EH&S for more information regarding these chemicals.

EH&S will promptly notify the worker and his/her PI/Laboratory Supervisor of the results in writing) after the receipt of any monitoring results. EH&S will establish and maintain an accurate record of any measurements taken to monitor exposures for each Chapman personnel. Records, including monitoring provided by qualified vendors, will be managed in accordance with CCR Title 8 Section 3204 “Access to Employee Exposure and Medical Records.”

Exposure Assessment Use to Determine and Implement Controls

EH&S will use any of the following criteria to determine required control measures to reduce employee's occupational exposure:

- Verbal information obtained from employees regarding chemical usage
- Visual observations of chemical use or laboratory operations
- Evaluation of existing engineering control measures or administrative practices
- Recommendations expressed in Safety Data Sheets (SDS)
- Regulatory requirements of Cal/OSHA
- Recommendations from professional industrial hygiene organizations
- Direct reading instrumentation results
- Employee exposure monitoring results; and/or
- Medical evaluation, examination and/or surveillance findings

Particular attention shall be given to the selection of safety control measures for chemicals that are known to be extremely hazardous. Per Cal/OSHA CCR Title 8 Section 5141 "Control of Harmful Exposure to Employees," the control of harmful exposures shall be prevented by implementation of control measures in the following order:

- Engineering controls, whenever feasible
- Administrative controls whenever engineering controls are not feasible or do not achieve full compliance and administrative controls are practical
- Personal protective equipment, including respiratory protection, during:
  - the time period necessary to install or implement feasible engineering controls
  - when engineering and administrative controls fail to achieve full compliance in emergencies
  - as an extra precaution/option for employees

Medical Evaluation

All employees, student workers, medical health services volunteers, or laboratory personnel who work with hazardous chemicals shall have an opportunity to receive a medical evaluation, including supplemental examinations which the evaluating physician determines necessary, under the following circumstances:

- Whenever an employee develops signs or symptoms associated with a hazardous chemical to which an employee may have been exposed in a laboratory
- Where personal monitoring indicates exposure to a hazardous chemical is above a Cal/OSHA Action Level (AL) or Permissible Exposure Limit (PEL) or recommended exposure levels established by the National Institute for Occupational Safety & Health (NIOSH) or the American Conference of Governmental Industrial Hygienists (ACGIH) in the event Cal/OSHA has not established an AL or PEL for a particular hazardous chemical
- Whenever an uncontrolled event takes place in the work area such as a spill, leak, explosion, fire, etc., resulting in the likelihood of exposure to a hazardous chemical; or

- Upon reasonable request of the employee to discuss medical issues and health concerns regarding work-related exposure to hazardous chemicals

All work-related medical evaluations and examinations will be performed by a medical facility. Any laboratory employee or student worker who exhibits signs and symptoms of adverse health effects from work-related exposure should file an incident report with Risk Management and contact Wellness & Leave Administration Specialist Tim Frenchcampbell at frenchca@chapman.edu.

Confidentiality & Individual's Access to Personal Medical Records
All patient medical information is protected by California and federal law and is considered strictly confidential. The medical facility is prohibited from disclosing any patient medical information that is not directly related to the work-related exposure under evaluation and should not reveal any diagnosis unrelated to exposure. Any patient information disclosed by the medical facility to the employee's supervisor will be limited to information necessary in assessing an employee's return to work, including recommended restrictions in work activities, if any. Any patient information disclosed by the medical facility to EH&S will be limited to information necessary to develop a course of exposure monitoring, or perform hazard assessments and incident investigations, if appropriate, the medical facility will otherwise disclose patient medical information only as required by California and Federal law, such as for Worker's Compensation Insurance claims. Each employee has the right to access his/her own personal medical and exposure records. The medical facility will provide an employee with a copy of his/her medical records upon written request.

Medical Surveillance
Medical surveillance is the process of using medical examinations, questionnaires and/or biological monitoring to determine potential changes in health as a result of exposure to a hazardous chemical or other hazards. Certain Cal/OSHA standards require clinical examination as part of medical surveillance when exposure monitoring exceeds an established Action Level or PEL. Chapman uses outside vendors for medical surveillance services. Medical surveillance is required of employees who are routinely exposed to certain hazards as part of their job description and may be offered to other employees based upon quantifiable or measured exposure. Examples of hazards that are monitored through the medical surveillance program may include: Asbestos, Beryllium, Formaldehyde, Lead, Methylene Chloride, Noise (Hearing Conservation Program), Radioactive Chemicals (Bioassay Program), Respirator Use (Respirator Protection Program), and other particularly hazardous substances. Individuals with questions regarding work-related medical surveillance are encouraged to contact EH&S for more information.

10.0 CHEMICAL PROCUREMENT, INVENTORY, HANDLING, STORAGE, AND TRANSPORTATION

Chemical Procurement

The procurement of chemicals by University research groups may be coordinated through the following:

- Directly through Chapman University's contract vendor(s);
- Senior Lab Supervisor, under the direction of the Dean of the respective College of Science
- Purchasing Department, University Services, Chapman University.
- The purchase of hazardous chemicals must be ordered through purchase requisition, properly coded to indicate hazardous materials, by way of the PeopleSoft and/or Concur system, and will be reviewed and approved by EH&S prior to approval by the Purchasing Department

Chemical Inventory

Regulatory Requirements

Implementation of the necessary work practices, procedures, and policies outlined in this chapter is required by the following:

- Title 8, California Code of Regulations (CCR), Section 5164, "Storage of Hazardous Substances"
- Title 8, CCR, Section 5191, "Occupational Exposures to Hazardous Chemicals in Laboratories"
- Title 8, CCR, Section 5194, "Hazard Communication"
- Title 8, CCR, Section 5209, "Carcinogens"
- Title 8, CCR, Section 5154.1, "Ventilation Requirements for Laboratory-Type Hood Operations"

An inventory must be maintained for all areas storing hazardous materials including compressed gas cylinders. The department lab technicians will be responsible for maintaining a current inventory of chemicals in the electronic chemical inventory control system. Chemicals will be tracked in this system from the time of purchase through the internal distribution and ultimate disposal. Each Principal Investigator (PI) will be responsible for maintaining their chemical inventory in the electronic chemical inventory system CHIMERA. Instructions for use of the system will be provided by Chapman University EH&S. Additional information is available in Appendix I Chemical Inventory Program. The CHIMERA system is used across the campus for this purpose.

Chemical Inventories

Faculty members and other supervisors with chemicals are required to use the campus inventory system to maintain a current, accurate and complete chemical inventory that includes the hazardous materials, solids, liquids gases and gels used and stored in the rooms to which they are assigned or allowed to be used. The information maintained in the inventory includes the name of the chemical, the concentration, the chemical abstracts number, the size of the container, the number of identical containers, the amount on hand, the physical state, the type of the container, whether it is pure or a mixture and both the storage pressure and temperature. Chemical inventories are used to provide the required information to the fire department, ensure compliance with fire code storage limits, and homeland security reporting thresholds. The chemical inventory can also be used in an emergency to identify potential hazards for emergency response operations and more.

The chemical inventory list should be reviewed prior to ordering new chemicals and only the minimum quantities of chemicals necessary for the research should be purchased. As new chemicals are added to the inventory, each laboratory group can confirm that they have access to the Safety Data Sheet (SDS) for that chemical through the CHIMERA SDS library. Where practical, each chemical should be dated so that expired chemicals can be easily identified for disposal. Inventory the materials in your laboratory at least annually to avoid overcrowding with materials that are no longer useful and note the items that should be replaced, have deteriorated, or show container deterioration. The Department of Homeland Security (DHS) maintains a list of "DHS Chemicals of Interest," and requires a report to be submitted within 60 days if specific chemicals on that list exceed set threshold aggregate amounts. As a result, everyone who has chemicals at Chapman University must update the on-line inventory when they are received or consumed/disposed. Unneeded items should be given to EH&S and compromised items should be discarded as chemical waste. Attributes that may indicate the materials need to be disposed are: cloudiness in liquids, a change in color, evidence of liquids in solids, or solids in liquids, "puddling" of material around outside of containers, pressure build-up within containers and obvious deterioration of containers in addition to exceeding a manufacturer's expiration date.

Access to hazardous chemicals, including toxic and corrosive substances, should be restricted at all times. These materials must be stored in laboratories or storerooms that are kept locked when laboratory personnel are not present. Locked storage cabinets or other precautions are always recommended, and in some cases may be required in the case of unusually toxic or hazardous chemicals. Unusually toxic chemicals may include those that are immediately dangerous to life or health (IDLH). For guidance on storage requirements, please contact EH&S.

On termination or transfer of laboratory personnel, all related hazardous materials should be properly disposed of, or transferred to the laboratory supervisor or a designee.

Chemical Labeling

All containers (including diluted chemical solutions and those with abbreviations) of hazardous materials must be labeled with the identity of the hazardous substance and all applicable hazard warning statements or abbreviations. If abbreviations are used, a list of the abbreviations used, the full chemical names and the hazards warning statement associated with each, must be prominently displayed in each room. In either case, all containers not actively being used in the transfer or the reaction must be labeled. New synthesized compounds must be labeled with the appropriate hazard warnings based on the knowledge of the chemical and physical properties of that substance.

Labels must be legible, in English, and clearly displayed; Lewis structures alone are inadequate. Secondary containers (such as spray bottles) must be labeled with the identity of the substance and appropriate hazard warnings.

Symbols and/or other languages may be provided for non-English speaking employees. Use the symbols in the Globally Harmonized System of Classification and Labeling of Chemicals.

Peroxide forming chemicals (e.g., ethers) must be labeled with a date on receipt and the date when the bottle is first opened. For the containers without a manufacturer supplied expiration date, these chemicals are only allowed a one year shelf life and must be disposed of as waste within one year of receipt or six months of opening. These chemicals can degrade to form shock sensitive, highly reactive compounds and should be stored and labeled very carefully.

Particularly Hazardous Substances require additional labeling to identify the specific hazard associated with each of these chemicals (carcinogen, reproductive toxin, acutely toxicant). In addition, the storage area where they are kept must be labeled with the type of hazard. These chemicals should be segregated from less hazardous chemicals to help with proper access control and hazard identification.

Chemical Handling

- Properly label and store all chemicals
- Deposit chemical waste in appropriate labeled containers and follow all other waste disposal procedures of the CHP
- Do not smell or taste chemicals
- Never use mouth suction for pipetting or starting a siphon
- Do not dispose of any hazardous chemicals through the sewer system
- Be prepared for an accident or spill and refer to the emergency response procedures for the specific material. Procedures should be readily available to all personnel. For general guidance, the following situations should be addressed:
    - Eye Contact: Promptly flush eyes with water for a prolonged period (15 minutes) and seek medical attention
    - Skin Contact: Promptly flush the affected area with water and remove any contaminated clothing. If symptoms persist after washing, seek medical attention

Chemical Storage and Segregation

Establish and follow safe chemical storage & segregation procedures for your laboratory. Storage guidelines are included for materials that are flammable, oxidizers, corrosive, and water reactive, explosive and highly toxic. The specific SDS should always be consulted when doubts arise concerning chemical properties and associated hazards. All procedures employed must comply with Cal/OSHA, Fire Code and building code regulations. Always wear appropriate personal protective equipment (e.g., laboratory coat, safety glasses, gloves, safety goggles, apron) when handling hazardous chemicals. Be aware of the locations of the safety showers and emergency eyewash stations. Each laboratory is required to provide appropriate laboratory-specific training on how to use this equipment prior to working with hazardous chemicals. The table below lists chemical safety storage priorities.

Safe Chemical Storage Priorities Table

Keep in mind that most chemicals have multiple hazards and a decision must be made as to which storage area would be most appropriate for each specific chemical. First you have to determine priorities:

1. Flammability. When establishing a storage scheme, the number one consideration should be the flammability characteristics of the material. If the material is flammable, it should be stored in a flammable cabinet
2. Isolate. If the material will contribute significantly to a fire (e.g., oxidizers), it should be isolated from the flammables. If there were a fire in the laboratory and response to the fire with water would exaggerate the situation, isolate the water reactive material away from contact with water
3. Corrosivity. Next look at the corrosivity of the material, and store accordingly
4. Toxicity. Finally, consider the toxicity of the material, with particular attention paid to regulated materials. In some cases, this may mean that certain chemicals will be isolated within a storage area. For example, a material that is an extreme poison but is also flammable, should be locked away in the flammable storage cabinet to protect it against accidental release.

There will always be some chemicals that will not fit neatly in one category or another, but with careful consideration of the hazards involved, most of these cases can be handled in a reasonable fashion.

Chemical Incompatibility Chart

THIS CHEMICAL	IS INCOMPATIBLE WITH
Acetic acid	Chromic acid, ethylene glycol, hydroxyl-containing compounds, nitric acid, perchloric acid, permanganates, peroxides
Acetone	Concentrated sulfuric and nitric acids and mixtures
Acetylene	Copper, mercury, silver, chlorine, bromine, fluorine
Alkali and Alkaline earth metals (such as powdered Al or Mg, Ca, Li, Na, K)	Water, carbon tetrachloride or other chlorinated hydrocarbons, carbon dioxide, halogens
Ammonia (anhydrous)	Bromine, chlorine, iodine
Ammonium nitrate	Acids, powdered metals, flammable liquids, chlorates, nitrites, sulfur, finely divided organic materials
Aniline	Hydrogen peroxide, nitric acid
Arsenical materials	Any reducing agent
Azides	Acids
Bromine and Chlorine	Ammonia, benzene, turpentine
Calcium oxide	Water
Carbon (activated)	Calcium hypochlorite, all oxidizing agents
Carbon tetrachloride	Sodium
Chlorates	Ammonium salts, acids, powdered metals, sulfur, finely divided organic or combustible materials
Chromic acid, Chromium dioxide	Acetic acid, alcohol, ethyl acetate, glycerol, naphthalene, camphor, flammable liquids in general
Copper	Acetylene, hydrogen peroxide
Cumene hydroperoxide	Acids (organic and inorganic)
Cyanides	Acids
Flammable liquids	Ammonium nitrate, chromic acid, hydrogen peroxide, nitric acid, sodium peroxide, halogens
Fluorine	All other chemicals
Formic acid	Oxidizing agents
Hydrazine	Oxidizing agents
Hydrocarbons (such as butane propane, benzene)	Fluorine, chlorine, bromine, chromic acid, sodium peroxide
Hydrocyanic acid	Nitric acid, alkali
Hydrofluoric acid	Ammonia (aqueous or anhydrous), hydrogen
Hydrogen peroxide	Acetone, alcohols, aniline, chromium, combustible materials, copper, iron, nitromethane, organic materials, most metals or their salts
Hydrogen sulfide	Fuming nitric acid, oxidizing gases
Hypochlorites	Acids, activated carbon
Iodine	Acetylene, ammonia, (aqueous or anhydrous), hydrogen
Mercury	Acetylene, fulminic acid, ammonia
Nitrates	Sulfuric acid
Nitroparaffins	Inorganic bases, amines
Oxalic acid	Silver, mercury
Oxygen	Oils, greases, hydrogen, flammable liquids, solids or gases

General Recommendations for Safe Storage of Chemicals

Each chemical in the laboratory should be stored in a specific location and returned there after each use. Acceptable chemical storage locations may include corrosive cabinets, flammable cabinets, laboratory shelves, or appropriate refrigerators or freezers. Fume hoods should not be used as storage areas for chemicals, as this may seriously impair the ventilating capacity of the hood. Additionally, bulk quantities of chemicals (i.e., larger than one-gallon or 4 liters) should be stored in a separate storage area, such as a stockroom or supply room.

Laboratory shelves should have a raised lip along the outer edge to prevent containers from falling. Hazardous liquids, toxic or corrosive chemicals should not be stored on shelves above eyelevel and chemicals which are highly toxic or corrosive should be in unbreakable secondary containers.

Chemicals must be stored at an appropriate temperature and humidity level and should never be stored in direct sunlight or near heat sources, such as laboratory ovens. Incompatible materials should be stored in separate cabinets, whenever possible. If these chemicals must be stored in one cabinet, due to space limitations, adequate segregation and secondary containment must be ensured to prevent adverse reactions. All stored containers and research samples must be appropriately labeled and tightly capped to prevent vapor interactions and to alleviate nuisance odors. Flasks with only septa, cork, rubber or glass stoppers should be avoided because of the potential for leaking.

Laboratory refrigerators and freezers must be labeled appropriately with “No Food/Drink” and must never be used for the storage of food or drinks intended for human consumption. Freezers should be defrosted periodically so that chemicals do not become trapped in ice formations. Never store peroxide formers (e.g., ether) in a refrigerator not specifically designed for storage of flammable liquids.

Flammable and Combustible Liquids in general should not be stored alongside combustible materials like paper and packaging nylon bags. Large quantities of flammable or combustible materials should not be stored in the laboratory. The Fire Code limits the specific volume of flammable materials or other classes of hazardous chemicals depending on the original design and construction of the facility and varies from building to building at Chapman University. In most B occupancy labs, the maximum total quantity of class 1A, 1B and 1C flammable liquids must not exceed 60 gallons, which must be stored in a flammable storage cabinet. The maximum quantity allowed to be kept outside a flammable storage cabinet, safety can, or approved refrigerator/freezer is 10 gallons (38 liters) per room. Class 1A solvents, such as ethyl ether, should be purchased only in one liter size containers. Because of the extreme flammability of the Class 1 liquids, only quantities needed for immediate use should be stored. Examples of equipment that can be used for storage include: flammable storage cabinets, flammable storage refrigerators or freezers that are designed and UL approved for the storage of flammable substances, or approved safety cans or drums that are grounded. Always segregate flammable or combustible liquids from oxidizing acids and oxidizers. Flammable materials must never be stored in domestic-type refrigerators/freezers and should not be stored in a refrigerator/freezer if the chemical has a flash point below the temperature of the equipment. Flammable or combustible liquids must not be stored on the floor or in any exit access.

Handle flammable and combustible substances only in areas free of ignition sources and use the chemical in a fume hood whenever practical. Only the amount of material required for the experiment or procedure should be stored in the work area. Always transfer flammable and combustible chemicals from glass containers to glassware or from glass container/glassware to plastic. Transferring these types of chemicals between plastic containers may lead to a fire hazard due to static electricity. The transfer of flammable liquid from 5 gallon (19 liters) or larger metal containers should not be done in the laboratory.

Hazard classification for flammable liquids			
Class	**Flash point**	**Boiling point**	**Examples**
I-A	below 73°F (23°C)	below 100°F (38°C)	diethyl ether, pentane, ligroin, petroleum ether
I-B	below 73°F (23°C)	at or above 100°F (38°C)	acetone, benzene, cyclohexane, ethanol
I-C	73-100°F (24-38°C)	----	p-xylene
Hazard classification for combustible liquids			
II	101-140°F (39-60°C)	----	diesel fuel, motor oil, kerosene, cleaning solvents
III-A	141-199°F (61-93°C)	----	paints (oil base), linseed oil, mineral oil
III-B	200°F (93°C) or above	----	paints (oil base), neatsfoot oil

Pyrophoric & Water Reactive Substances
Because pyrophoric substances can spontaneously ignite on contact with air and/or water, they must be handled under an inert atmosphere and in such a way that rigorously excludes air and moisture. Some pyrophoric materials are also toxic and many are dissolved or immersed in a flammable solvent. Other common hazards include corrosivity, teratogenicity, or peroxide formation.

Only minimal amounts of reactive chemicals should be used in experiments or stored in the laboratory. These chemicals must be stored as recommended in the SDS. Reactive materials containers must be clearly labeled with the correct chemical name, in English, along with a hazard warning.

Suitable storage locations may include inert gas-filled desiccators or glove boxes; however, some pyrophoric materials must be stored in a flammable substance approved freezer. If pyrophoric or water reactive reagents are received in a specially designed shipping, storage or dispensing container (such as the Aldrich Sure/Seal packaging system), ensure that the integrity of that container is maintained. Ensure that sufficient protective solvent, oil, kerosene, or inert gas remains in the container while pyrophoric materials are stored. Never store reactive chemicals with flammable materials or in a flammable liquids storage cabinet.

Storage of pyrophoric gases is described in the California Fire Code, Chapter 41. Gas cabinets, with remote sensors and fire suppression equipment, are required. Gas flow, purge and exhaust systems should have redundant controls to prevent pyrophoric gas from igniting or exploding. Emergency back-up power should be provided for all electrical controls, alarms and safeguards associated with the pyrophoric gas storage and process systems. EH&S should be notified prior to any use of these gases for special approval

Never return excess reactive chemical to the original container. Small amounts of impurities introduced into the container may cause a fire or explosion. For storage of excess chemical, prepare a storage vessel in the following manner:

- Dry any new empty containers thoroughly
- Insert the septum into the neck in a way that prevents atmosphere from entering the clean dry (or reagent filled) flask
- Insert a needle to vent the flask and quickly inject inert gas through a second needle to maintain a blanket of dry inert gas above the reagent
- Once the vessel is fully purged with inert gas, remove the vent needle then the gas line. To introduce the excess chemical, use the procedure described in the handling section of the SOP
- For long-term storage, the septum should be secured with a copper wire or hose clamp
- For extra protection a second same-sized septa (sans holes) can be placed over the first; and
- Use “Parafilm M®” or equivalent around the outer septa and remove the Parafilm M® and outer septum before accessing the reagent through the primary septum.

Oxidizers
Oxidizers (e.g., oxygen, ozone, hydrogen peroxide, and other inorganic peroxides; fluorine, chlorine, and other halogens; nitric acid and nitrate compounds; persulfuric acids; chlorite, chlorate, perchlorate, and other analogous halogen compounds; hypochlorite and other hypohalite compounds, including household bleach; hexavalent chromium compounds such as chromic and dichromic acids and chromium trioxide, pyridinium chlorochromate, and chromate/dichromate compounds; permanganate compounds; sodium perborate; nitrous oxide; silver oxide; osmium tetroxide; Tollens' reagent; 2,2'- dipyridyldisulfide) should be stored in a cool, dry place and kept away from flammable and combustible materials, such as wood, paper, StyrofoamTM, most plastics, flammable organic chemicals, and away from reducing agents, such as zinc, alkaline metals, and formic acid.

Peroxide Forming Chemicals

Peroxide forming chemicals (e.g., acetaldehyde diethyl acetal (acetal); cumene (isopropyl benzene); cyclohexene ; cyclopentene; decalin (decahydronaphthalene); diacetylene (butadiene); diethyl ether (ether); diethylene glycol dimethyl ether (diglyme); diisopropyl ether (isopropyl ether); dioxane; divinylacetylene (DVA); ethylene glycol dimethyl ether (glyme); ethylene glycol ether acetates; ethylene glycol monoethers (cellosolves); furan; inylidene chloride (1, 1-di-chloroethylene); methylacetylene; methylcyclopentane; potassium amide; potassium metal ; sodium amide (sodamide); tetrahydrofuran (THF); tetralin (tetrahydronapthalene); vinyl ethers) should be stored in airtight containers in a dark, cool, and dry place and must be segregated from other classes of chemicals that could create a serious hazard to life or property should an accident occur (e.g., acids, bases, oxidizers). The containers should be labeled with the date received and the date opened. This information, along with the chemical identity should face forward to minimize container handling during inspection. These chemicals must also be tested and documented for the presence of peroxides periodically. Minimize the quantity of peroxide forming chemicals stored in the laboratory and dispose of peroxide forming chemicals before peroxide formation.

Carefully review all cautionary material supplied by the manufacturer prior to use. Avoid evaporation or distillation, as distillation defeats the stabilizer added to the solvents. Ensure that containers are tightly sealed to avoid evaporation and that they are free of exterior contamination or crystallization. Never return unused quantities back to the original container and clean all spills immediately.

If old containers of peroxide forming chemicals are discovered in the laboratory, (greater than two years past the expiration date or if the date of the container is unknown), do not handle the container. If crystallization is present in or on the exterior of a container, do not handle the container. Secure it and contact EH&S for special disposal by an outside contractor

Corrosives

Store corrosive chemicals (i.e., acids, bases) below eye level and in secondary containers that are large enough to contain at least 10% of the total volume of liquid stored or the volume of the largest container, whichever is greater. Acids must always be segregated from bases and from active metals (e.g., sodium, potassium, magnesium) at all times and must also be segregated from chemicals which could generate toxic gases upon contact (e.g., sodium cyanide, iron sulfide). Specific types of acids require additional segregation. Mineral acids must be kept away from organic acids and oxidizing acids must be segregated from flammable and combustible substances. Perchloric acid should be stored by itself, away from other chemicals. Picric acid is reactive with metals or metal salts and explosive when dry and must contain at least 10% water to inhibit explosion.

Special Storage Requirements

Compressed Gas Cylinders

Compressed gas cylinders that are stored must be chained or strapped to the wall or other stable building member, with the safety cap in place. The cylinders must be restrained by two chains or straps; one chain must be placed at one third from the top of the cylinder, and the other placed at one third from the bottom of the cylinder. If this is not practical, contact EH&S for guidance. Although free standing floor mounted stands are preferred, bolted “clam shells” may be used in instances where gas cylinders must be stored or used away from the wall. Store liquefied fuel-gas cylinders securely in the upright position.

Cylinders are not to be stored in a horizontal position. Do not expose cylinders to excessive dampness, corrosive chemicals or fumes.

Certain gas cylinders require additional precautions. Flammable gas cylinders must use only flame resistant gas lines and hoses which carry flammable or toxic gases from cylinders and must have all connections wired. Compressed oxygen gas cylinders must be stored at least 20 feet (6 meters) away from combustible materials and flammable gases.

Gas cylinder connections must be inspected frequently for deterioration and must never be used without a regulator. Never use a leaking, corroded or damaged cylinder and never refill compressed gas cylinders. When stopping a leak between cylinder and regulator, always close the valve before tightening the union nut. The regulator must be replaced with a safety cap when the cylinder is not in use. Move gas cylinders with the safety cap in place using carts designed for this purpose.

Liquid Nitrogen

Because liquid nitrogen containers are at low pressure and have protective rings mounted around the regulator, they need to be affixed to a permanent fixture such as a wall to prevent them from walking or rolling into the egress path in an earthquake. However, additional protection considerations should be addressed when storing liquid nitrogen in a laboratory. The primary risk to laboratory personnel from liquid nitrogen is skin or eye thermal damage caused by contact with the material. In addition, nitrogen expands 696:1 when changing from a cryogenic liquid to a room temperature gas. The gas is not toxic, but if too much oxygen is displaced, asphyxiation is a possibility. Always use appropriate thermally insulated gloves when handling liquid nitrogen. Face shields may be needed in cases where splashing can occur.

Transportation

On-Campus

University staff may be required to transport small quantities of chemicals within the building from one laboratory to another or from the stockroom to the location where they will ultimately be used. Observing safe work-practices is essential when performing this task to prevent accidental releases or exposures.

The following guidelines serve as the minimum acceptable practices for transporting toxic, flammable, reactive, or corrosive chemicals on campus. However, individual academic or administrative departments may establish more stringent requirements for transportation of such materials. Note: These guidelines do not apply to radioactive materials or gas cylinders. For information on transporting these items contact EH&S.

- Use bottle carriers for transporting chemicals which are in glass containers and ensure that the caps are securely tightened. NOTE: Never transport in-compatible chemicals in the same secondary containment
- While being transported, chemicals should be placed in a basin or tray and moved on carts to contain any spill
- If chemicals are being transported in a passenger elevator, ensure that the car is unoccupied
- For off-campus relocation or over-the-road transportation, contact EH&S for assistance. NOTE: The use of personal vehicles to transport chemicals is strictly prohibited
- Containers must be labeled with the material's chemical name and its hazards and attended at all times while being transported
- Individuals transporting chemicals must be familiar with the material's hazards and know what to do in the event of a release or spill
- Wear appropriate PPE such as safety glasses, lab coats, and impermeable gloves
- Immediately update the chemical inventory in CHIMERA to reflect the relocation of chemicals

Off- Campus
The transportation of hazardous chemicals and compressed gases over public roads, or by air, is strictly governed by international, federal, and state regulatory agencies, including the U.S. Department of Transportation (DOT) and the International Air Transport Association (IATA). Any person who prepares and/or ships these types of materials must ensure compliance with pertinent regulations regarding training, quantity, packaging, and labeling. Without proper training and packaging, it is illegal to ship hazardous materials. Those who violate the hazardous materials shipment regulations are subject to criminal investigation and penalties. Contact EH&S for more information.

Laboratory Safety and Emergency Response Equipment

New personnel must be instructed in the location of fire extinguishers, safety showers, and other safety equipment before they begin work in the laboratory. This training is considered part of the laboratory specific training that all staff members must attend.

Fire Extinguishers
All laboratories working with combustible chemicals, flammable chemicals, or other potential ignition sources (e.g. lasers) must be outfitted with appropriate fire extinguishers. All extinguishers should be mounted on a wall in an area free of clutter or stored in a fire

extinguisher cabinet. Research personnel should be familiar with the location, use and classification of the extinguishers in their laboratory. Laboratory personnel are not required to extinguish fires that occur in their work areas and should not attempt to do so unless:

- It is a small fire (i.e. small trash can sized fire); and
- Appropriate training has been received; and
- It is safe to do so

Any time a fire extinguisher is used, no matter for how brief a period, the PI/Laboratory Supervisor, or most senior laboratory personnel present at the time of the incident, must immediately report the incident to EH&S. Contact Fire and Life Safety for all Fire Safety Training needs.

Eyewashes & Safety Showers

Accidental chemical exposures can still occur even with good engineering controls, personal protective equipment and safety precautions. Emergency eye/face washes and showers provide an immediate mechanism to mitigate chemical exposure and further injury by allowing all personnel a method of decontaminating areas of the body which have been exposed to an injurious material.

All laboratories using hazardous chemicals must have immediate access to safety showers with eye wash stations. Access must be available in an unlocked location within 10 seconds or less for a potentially injured individual and access routes must be kept clear. This requirement applies to all areas where, during routine operations or emergencies, the eyes or body of an employee may come in contact with a substance that could cause corrosion, severe irritation, or permanent tissue damage, or is toxic by absorption. Safety showers must have a minimum clearance of 16 inches (41 cm) from the centerline of the spray pattern in all directions at all times; this means that no objects should be stored or left within this distance of the safety shower.

In the event of an emergency, individuals using the safety shower should be assisted by an uninjured person to aid in decontamination and should be encouraged to stay in the safety shower for at least 15 minutes to remove all hazardous material. Safety shower/eyewash stations are tested by Facilities Management. Any units which do not have a testing date should be reported immediately to EH&S If an eyewash or safety shower needs repair, a work order must be given to Facilities Management. Any questions regarding the procedure for placing a work order should be directed to Facilities Management.

Fire Doors

Many areas may contain critical fire doors as part of the building design. These doors are an important element of the fire containment system and should remain closed unless they are on a magnetic self-closing or other automated self-closing system.

Laboratory Security

Regulatory agencies have implemented rules to ensure chemical security. While many of these rules are for large manufacturing facilities, it is critical that chemicals be secured to prevent theft from campus laboratories. Numerous federal agencies are involved in the maintenance of laboratory security, including the Drug Enforcement Agency, Federal Bureau of Investigations, and Department of Homeland Security. It is each laboratory's responsibility to prevent and report any theft of chemicals from their laboratory. Laboratories are encouraged to conduct a Security Value Assessment (SVA). Aspect that should be covered in a SVA include:

- Existing threats, based on the history of the institution (e.g., theft of laboratory materials, sabotage, data security breaches, protests)
- The attractiveness of the institution as a target, and the potential impact of an incident
- Chemicals, biological agents, radioactive materials, or other laboratory equipment or materials with dual-use potential
- Sensitive data or computerized systems
- Animal care facilities
- Infrastructure vulnerabilities (e.g., accessible power lines, poor lighting)
- Security systems in place (e.g., access control, cameras, intrusion detection)
- Access controls for laboratory personnel (e.g., background checks, authorization procedures, badges, key controls, escorted access)
- Institutional procedures and culture (e.g., tailgating, open laboratories, no questioning of visitors)
- Security plans in place
- Training and awareness of laboratory personnel

Labs can increase their security by simply keeping lab doors closed and locked when unoccupied, maintaining a current and accurate chemical inventory, training personnel on security procedures, and controlling access to keys. Labs should report any suspicious activity to Public Safety at (714) 997-6963 and EH&S.

Training and Communication

Effective training is critical to facilitate a safe and healthy work environment and prevent laboratory accidents. All Faculty/Other Laboratory Supervisors must participate in formal safety training and ensure that all their employees have appropriate safety training before working in a laboratory.

Types of Training

All laboratory personnel must complete general laboratory safety training and lab specific training before:

1. Beginning work in the laboratory
2. Prior to new exposure situations
3. As work conditions change

Annual refresher training is also required for all laboratory personnel. EH&S offers online training, plus resource materials to assist laboratories in implementing laboratory-specific training

General Laboratory Safety Training
Anyone working in a laboratory is required to complete the online Introduction to Laboratory Safety Training Part A/B, Hazardous Waste Training, Chemical Storage and Compatibility, and other science safety courses deemed necessary by EH&S. These courses cover:

- Review of laboratory rules and regulations, including the Chemical Hygiene Plan
- Recognition of laboratory hazards
- Use of engineering controls, administrative controls and PPE to mitigate hazards
- Exposure limits for hazardous chemicals
- Signs and symptoms associated with exposures to hazardous chemicals
- Chemical exposure monitoring
- Review of reference materials (e.g., SDS) on hazards, handling, storage and disposal of hazardous chemicals
- Procedures for disposing of hazardous chemical waste
- Fire safety and emergency procedures
- Recordkeeping

Laboratory-Specific Training
Faculty/ Laboratory Supervisors must also provide laboratory-specific training. Topics that require specific training include:

- Location and use of the Chemical Hygiene Plan, IIPP, SDS(s) and other regulatory information
- Review of IIPP and Emergency Management Plan, including location of emergency equipment and exit routes
- Specialized equipment
- SOPs
- PPE
- Specialized procedures and protocols
- Particularly Hazardous Substances including physical and health hazards, potential exposure, medical surveillance, and emergency procedures
- On-site safety training; work-site specific

Documentation of Training
Accurate recordkeeping is a critical component of health and safety training. Per OSHA regulations, departments or laboratories are responsible for documenting health and safety training, including safety meetings, one-on-one training, and classroom and online training. Documentation can be maintained in the Laboratory Safety Manual.

Lab Evaluations and Compliance

Regulatory Requirements

Implementation of the necessary work practices, procedures, and policies outlined in this chapter is required by the following:

- Title 8, California Code of Regulations (CCR), Section 5191, "Occupational Exposures to Hazardous Chemicals in Laboratories"

Other applicable regulations include those promulgated by the U.S. Department of Labor including 29 CFR 1910.1450 "Occupational Exposure to Hazardous Chemicals in Laboratories" (the "Laboratory Standard").

Laboratory Safety Evaluations

EH&S has a comprehensive laboratory safety evaluation program to assist laboratories and other facilities that use, handle or store hazardous chemicals to maintain a safe work environment. This program helps to ensure compliance with regulations and to fulfill Chapman's commitment to protecting the health and safety of the campus community.

As part of this laboratory safety program, EH&S conducts periodic inspections of laboratories and other facilities with hazardous chemicals to ensure the laboratory is operating in a safe manner and to ensure compliance with all federal, state and university safety requirements. The primary goal of lab evaluations is to identify both existing and potential accident-causing hazards, actions, faulty operations and procedures that can be corrected before an accident occurs. EH&S may suspend or restrict any operation that "presents a significant (real or potential) imminent hazard associated with life safety, or the health and welfare of campus personnel or the public" until that hazardous condition or activity is abated.

The laboratory safety evaluation is comprehensive in nature and examines all key aspects of working with hazardous chemicals. While evaluations are a snapshot in time and cannot identify every accident causing mistake, they do provide important information on the overall operation of a particular laboratory. They can also help to identify weaknesses that may require more systematic action across a broader spectrum of laboratories, and strengths that should be fostered in other laboratories. Laboratory evaluations categories include:

- Documentation and Training
- Emergency and Safety Information
- Fire Safety
- General Safety
- Use of PPE
- Housekeeping
- Chemical Storage
- Fume Hood
- Chemical Waste Disposal and Transport
- Seismic Safety

- Mechanical and Electrical Safety

Planned, focused assessments are also conducted. Examples of these include industrial hygiene assessments and unannounced PPE inspections. Once the evaluations are completed, EH&S issues a Lab Survey Report. The report identifies deficiencies in the laboratory, both critical and non-critical. Critical deficiencies are those that have the potential to lead to serious injuries or be of critical importance in the event of an emergency. These deficiencies must be immediately corrected. Non-critical deficiencies must be corrected within 30-days. Any deficiency that requires a “Facilities Management Work Order” for completion will be added to the Facilities Management Work Order system so that it can be expedited by Facilities Management.

Notification and Accountability

The laboratory evaluation program requires that Faculty/ Laboratory Supervisors and other responsible parties take appropriate and effective corrective action upon receipt of written notification of evaluation findings. Critical deficiencies are required to be corrected within 48 hours; non-critical deficiencies must be corrected within 30 days. Failure to take corrective actions within the required timeframe will result in an escalation of the notification to the Department Chair, Dean, and any other upper-level staff. Depending on the severity of the deficiency, EH&S, in consultation with the Department Chair, Dean, and Provost, may temporarily suspend research activities until the violation is corrected. In some cases, the PI may be required to provide a corrective action plan to EH&S prior to resumption of research activities.

Recordkeeping

Accurate recordkeeping demonstrates a commitment to the safety and health of the Chapman community, integrity of research, and protection of the environment. EH&S is responsible for maintaining records of inspections, accident investigations, equipment calibration, and training conducted by EH&S staff. Documentation of training conducted by EH&S can be accessed via the LearnUpon, the Learning Management System (LMS). Per OSHA regulations, departments or laboratories must document health and safety training, including safety meetings, one-on-one training, and classroom and online training. Additionally, the following records must be retained in accordance with the requirements of state and federal regulations:

- Accident records – 5 years
- Laboratory evaluation reports – 5 years
- Measurements taken to monitor employee exposures – 30 years
- Chemical Hygiene Plan records should document that the facilities and precautions were compatible with current knowledge and regulations
- Inventory and usage records for high-risk substances should be kept
- Any medical consultation and examinations, including tests or written opinions required by CCR, Title 8, Section 5191 – duration of employment plus 30 years
- Medical records must be retained in accordance with the requirements of state and federal regulations – duration of employment plus 30 years

11.0 HAZARDOUS CHEMICAL WASTE MANAGEMENT

Regulatory Requirements

In California, hazardous waste is regulated by the Department of Toxic Substance Control (DTSC), a division within the California Environmental Protection Agency (Cal/EPA). Federal EPA regulations also govern certain aspects of hazardous waste management, since most of our waste is treated and disposed of out of state. These hazardous waste regulations are part of the Resource Conservation and Recovery Act, or RCRA. Local enforcement authority is administered by the County of Orange Health Care Agency Environmental Health Division and by the local Certified Unified Program Agency, CUPA in partnership with the Orange City Fire Department.

Hazardous Waste Program

The EH&S Hazardous Waste Program manages the disposal of all hazardous waste generated on both the Orange and Irvine campuses. Each laboratory employee must comply with the campus Hazardous Waste Management Program requirements and all applicable regulations.. Laboratory personnel are responsible for identifying, segregating, labeling, and storing hazardous waste properly in the laboratory. Laboratory clean-outs and disposal of high hazard compounds must be scheduled weeks in advance. The PI/Laboratory Supervisor is responsible for coordinating the disposal of all hazardous materials from his/her laboratories prior to closing down laboratory operations.

Definition of Hazardous Waste

Federal and State regulations define hazardous wastes as a substance which poses a hazard to human health or the environment when improperly managed. A chemical waste is considered hazardous if it is either listed on one of the lists found in Federal or State regulations or if it exhibits one or more of the four following characteristics:

1. Ignitable - ignitable wastes generally are liquids with a flash point below 60°C or 140°F (however, just because a material has a higher flash point, it still cannot be drain disposed)
2. Corrosive - corrosive wastes are generally aqueous wastes with a pH less than or equal to two (2) or greater than or equal to (12.5). Solutions that pH out of this range have the possibility of being hazardous. Please contact EH&S for clarification
3. Reactive - reactive wastes are those wastes that are unstable, explosive, and capable of detonation or react violently with water.
4. Toxic - a chemical that poses a hazard to health or the environment
    a. Has an acute oral LD50 less than 2,500 mg/kg
    b. Has an acute dermal LD50 less than 4,300 mg/kg
    c. Has an acute inhalation LC50 less than 10,000 ppm as a gas or vapor
    d. Has an acute aquatic 96-hour LC50 less than 500 mg/l
    e. Has been shown through experience or testing to pose a hazard to human health or environment because of its ability to cause cancer or mutation (carcinogen,

mutagen, teratogen), acute toxicity, chronic toxicity, bio-accumulative properties, or persistence in the environment

The EPA definition of hazardous waste also extends to the following items:

- Abandoned chemicals
- Unused or unwanted chemicals
- Chemicals in deteriorating containers
- Empty containers that have visible residues
- Containers with conflicting labels
- Unlabeled or unknown chemicals

Chemicals not in frequent use must be carefully managed to prevent them from being considered a hazardous waste. This is especially true for certain compounds that degrade and destabilize over time and require careful management so that they do not become a safety hazard.

Extremely Hazardous Waste

Certain compounds meet an additional definition known as "extremely hazardous waste". This list of compounds includes carcinogens, pesticides, and reactive compounds, among others (e.g., formaldehyde, chloroform, and hydrofluoric acid). The Federal EPA refers to this waste as "acutely hazardous waste", but Cal/EPA has published a more detailed list of extremely hazardous waste. NOTE: While there is some overlap with the list of Particularly Hazardous Substances, the extremely hazardous waste list is specific to hazardous waste management.

Proper Hazardous Waste Management

Training All personnel who handle, manage or dispose of hazardous waste must complete training prior to working with these materials. The EH&S online Hazardous Waste Management training course covers the hazardous waste program requirements and includes training on container labeling. Contact EH&S to be enrolled in the Hazardous Waste Management training course which must be updated on an annual basis.

Waste Identification

All the chemical constituents in each hazardous waste stream must be accurately identified by knowledgeable laboratory personnel. This is a critical safety issue for both laboratory employees and the waste technicians that handle the waste once it is turned over to EH&S. Mixing of incompatible waste streams has the potential to create violent reactions and is a common cause of laboratory accidents. If there is uncertainty about the composition of a waste stream resulting from an experimental process, laboratory workers must consult the PI/Laboratory Supervisor or the Chemical Hygiene Officer. In most cases, careful documentation and review of all chemical products used in the experimental protocol will result in accurate waste stream characterization.

The manufacturer's SDS provides detailed information on each hazardous ingredient in laboratory reagents and other chemical products, and also the chemical, physical, and toxicological properties of that ingredient. CHIMERA's SDS library provides an extensive library of research chemicals. Waste streams that have a large percentage of ingredients listed as proprietary information should be discussed with the EH&S.

Labeling

Hazardous waste labels must be placed on the hazardous waste container upon the start of accumulation. Each label must be completed accurately, and updated as the contents of the waste container change. Product names or abbreviations for waste container ingredients should not be used. For labeling needs, refer to: https://www.chapman.edu/faculty-staff/environmental/waste.aspx

Storage

The hazardous waste storage area in each laboratory is considered a Satellite Accumulation Area (SAA). According to EPA requirements, this area must remain under the control of the persons producing the waste. This means that it should be located in an area that is supervised and is not accessible to the public. Other SAA requirements include:

- Hazardous waste containers must be labeled
- Waste must be collected and stored at or near the point of generation
- All hazardous waste containers in the laboratory must be kept closed when not in use
- Hazardous waste streams must have compatible constituents, and must be compatible with the containers in which they are stored
- Liquid hazardous waste containers must be stored in secondary containment at all times
- Containers must be in good condition with leak proof lids
- Allow at least one inch (3 cm) of headspace in the containers to prevent spillage on Dry wastes must be double-bagged in clear, 3-mil plastic bags
- Do not dispose of chemicals by pouring them down the drain or placing them in the trash

Segregation

All hazardous materials must be managed in a manner that prevents spills and uncontrolled reactions. Stored chemicals and waste should be segregated by hazard class. Examples of proper segregation are:

- First segregate liquids and solids
- Segregate the following:
    - Acids pH 2 or less (Do not mix with other acids)
    - Alkaline solutions of pH 12.5 or greater (Do not mix with other bases)
    - Alkali metals and other water reactives
    - Heavy metal solutions and salts
    - Flammables and combustibles

- Peroxide forming chemicals
- Strong oxidizers
- Chemical carcinogens
- Cyanides
- Other toxic materials

Segregation of waste streams should be conducted in a similar manner to segregation of chemical products.

Incompatible Waste Streams

Mixing incompatible waste streams, or selecting a container that is not compatible with its contents, is a common cause of accidents in laboratories and waste storage facilities. Reactive mixtures can rupture containers and explode, resulting in serious injury and property damage. All chemical constituents and their waste byproducts must be compatible for each waste container generated. Waste tags must be immediately updated when a new constituent is added to a mixed waste container, so that others in the laboratory will be aware and manage it accordingly.

Some common incompatible waste streams include:

- Oxidizers added to any fuel can create an exothermic reaction and explode. The most frequent is acids oxidizing flammable liquids. For this reason, all flammable liquids are pH tested before they are consolidated

Wastes That Require Special Handling

Unknowns

Unlabeled chemical containers and unknown/unlabeled wastes are considered unknowns, and additional fees must be paid to have these materials analyzed and identified. These containers must be labeled with the word "unknown". To help prevent this, label all your products and use a hazardous waste label as soon as one drop of waste is placed into a container.

Peroxide Forming Chemicals

Peroxide forming chemicals, or PFCs, include a number of substances that can react with air, moisture or product impurities, and undergo a change in their chemical composition during normal storage. The peroxides that form are highly reactive and can explode upon shock or spark. Peroxides are not particularly volatile and thus tend to precipitate out of liquid solutions. It is particularly dangerous to allow a container of these materials to evaporate to dryness, leaving the crystals of peroxide on the surfaces of the container. Each container of peroxide forming chemicals should be dated with the date received and the date first opened. There are three classes of peroxide forming chemicals, with each class having different management guidelines. A review of the safety information provided by the manufacturer can be used as a guide to managing PFCs. Ensure containers of PFCs are kept tightly sealed to avoid unnecessary evaporation, as this inhibits the stabilizers that are sometimes added. Visually inspect containers periodically to ensure that they are free of exterior contamination or crystallization. PFC containers must be disposed of prior to expiration date. If old containers of peroxide forming chemicals are discovered in the laboratory, (greater than two years past the expiration date or if the date of the container is unknown), do not handle the container. If crystallization is present in or on the exterior of a container, do not handle the container. Secure it and contact the EH&S.

Dry Picric Acid

Picric acid (also known as 2,4,6-trinitrophenol) must be kept hydrated at all times, as it becomes increasingly unstable as it loses water content. When dehydrated, it is not only explosive but also sensitive to shock, heat and friction. Picric acid is highly reactive with a wide variety of compounds (including many metals which is why it must be stored in glass containers) and is extremely susceptible to the formation of picrate salts. Be sure to label all containers that contain picric acid with the date received, and then monitor the water content every 6 months. Add distilled water as needed to maintain a consistent liquid volume. If old or previously unaccounted for bottles of picric acid are discovered, do not touch the container. Depending on how long the bottle has been abandoned and the state of the product inside, even a minor disturbance could be dangerous. Visually inspect the contents of the bottle without moving it to evaluate its water content and look for signs of crystallization inside the bottle and around the lid. If there is even the slightest indication of crystallization, signs of evaporation, or the formation of solids in the bottle, do not handle the container and contact EH&S immediately. Secure the area and restrict access to the container until it can be evaluated by EH&S.

Explosives and Compounds with Shipping Restrictions

A variety of other compounds that are classified as explosives or are water or air reactive are used in research laboratories. These compounds often have shipping restrictions and special packaging requirements. When disposing of these compounds, employees must ensure that they are stored appropriately for transport. Flammable metals must be completely submerged in oil before they are brought to a waste pick-up. Many pyrophoric and reactive compounds can be stabilized using a quenching procedure prior to disposal. Chemicals classified by the Department of Transportation (DOT) as explosives (e.g., many nitro- and azo- compounds) will require special packaging and shipping, and may require stabilization prior to disposal. Consult EH&S for disposal considerations of these compounds.

Transportation

It is a violation of DOT regulations to transport hazardous waste in personal vehicles, or to carry hazardous waste across campus streets that are open to the public. As a result, EH&S contracts pick-up services for all hazardous waste generators. Special pick-ups and laboratory clean-outs are available upon request.

Accumulation and Disposal

Frequent disposal will ensure that hazardous waste accumulation areas in labs are managed properly, and that accumulation limits are not exceeded. Chapman policy states that hazardous chemical waste can be stored in a laboratory for up to 5 months . Once a waste container is full leaving at least 1 inch (3 cm) of headspace or it is near the 5 month time limit, it should be transferred to the hazardous waste storage area.

Hazardous Waste Minimization

In order to reduce the amount of chemicals that become waste, administrative and operational waste minimization controls can be implemented. Usage of chemicals in laboratory areas should be reviewed to identify practices which can be modified to reduce the amount of hazardous waste generated. To minimize the costs, health hazards, and environmental impacts associated with the disposal of hazardous waste, below are some guidelines regarding waste minimization:

- Purchasing Control: Check the inventory before new products are ordered. When ordering chemicals, be aware of any properties that may preclude long term storage, and order only exact volumes to be used. Purchasing smaller quantities of chemicals are required by Orange City Fire DepartmentUsing suppliers who can provide quick delivery of small quantities can assist with reducing surplus chemical inventory
- Inventory Control: Rotate chemical stock to keep chemicals from becoming outdated. Identify surplus/unused chemicals and attempt to redistribute these to other users, or consider giving them to EH&S
- Operational Controls: Review your experimental protocol to ensure that chemical usage is minimized. Reduce total volumes used in experiments; employ small scale procedures when possible. Instead of wet chemical techniques, use instrumental methods, as these generally require smaller quantities of chemicals. Evaluate the costs and benefits of off-site analytical services. Avoid mixing hazardous and non-hazardous waste streams. Use less hazardous or non-hazardous substitutes when feasible. Some examples include:
    - Specialty detergents can be substituted for sulfuric acid/chromic acid cleaning solutions
    - Gel Green and Gel Red are recommended in place of ethidium bromide

Drain Disposal

Chapman does not permit drain disposal of chemical wastes. Drain disposal of properly disinfected infectious or biohazardous liquids is acceptable, if disinfection is conducted as specified by the EH&S Biosafety Program, and the liquids disposed contain no other hazardous constituents.

12.0 EMERGENCY PREPAREDNESS

Overview

Laboratory emergencies may result from a variety of factors, including serious injuries, fires and explosions, spills and exposures, and natural disasters. All laboratory employees should be familiar with and aware of the location of their laboratory's emergency response plans and safety manuals. Before beginning any laboratory task, know what to do in the event of an emergency situation. Identify the location of safety equipment, including first aid kits, eye washes, safety showers, fire extinguishers, fire alarm pull stations, and spill kits. Plan ahead and know the location of the closest fire alarms, exits, and telephones in your laboratory. The Chapman Emergency Procedure poster provides an overview of emergency response procedures and should be posted in each laboratory. If a copy is needed, please contact EH&S.

For all incidents requiring emergency response, call Public Safety at (714) 997-6963.

Accidents and Incidents

PI/Laboratory Supervisors are responsible for ensuring that their employees receive appropriate medical attention in the event of an occupational injury or illness. All accidents and near misses must be reported to the supervisor and EH&S. An injury, incident or safety concern can also be reported to EH&S online https://www.chapman.edu/faculty-staff/risk-management/reporting.aspx. EH&S will conduct an accident investigation and develop recommendations and corrective actions to prevent future accidents. At a minimum, each laboratory must have the following preparations in place:

- Fully stocked first aid kit
- Posting of emergency telephone numbers and locations of emergency treatment facilities
- Training of staff to accompany injured personnel to medical treatment site and to provide medical personnel with copies of SDS(s) for the chemical(s) involved in the incident

If an employee has a severe or life threatening injury, call for emergency response at 911. Employees with minor injuries should be treated with first aid kits as appropriate, and sent to the appropriate facility for further evaluation and treatment. Treatment can be obtained after normal business hours at designated medical centers and emergency rooms.

Serious occupational injuries, illnesses, and exposures to hazardous substances must be reported to the supervisor and EH&S within 8 hours. EH&S will report the event to Cal/OSHA, investigate the accident, and complete exposure monitoring, if necessary. Serious injuries include those that result in permanent impairment or disfigurement, or require hospitalization. Examples include amputations, lacerations with severe bleeding, burns, concussions, fractures and crush injuries. As soon as Faculty/ Laboratory Supervisors are aware of a potentially serious incident, they must contact EH&S.

Fire-Related Emergencies

If you encounter a fire, or a fire-related emergency (e.g., abnormal heating, smoke, burning odor), immediately follow these instructions:

1. Pull the fire alarm pull station and call Public Safety
2. Evacuate and isolate the area
    a. Use portable fire extinguishers to facilitate evacuation and/or control a small fire (i.e., size of a small trash can), if safe to do so and if properly trained

b. If possible, shut off equipment before leaving
c. Close doors and/or fume hood sash

3. Remain safely outside the affected area to provide details to emergency responders
4. Evacuate the building when the alarm sounds. It is against state law to remain in the building when the alarm is sounding. If the alarm sounds due to a false alarm or drill, you will be allowed to re-enter the building as soon as the Fire Department determines that it is safe to do so. Do not go back in the building until the alarm stops and you are cleared to reenter.
5. If your clothing catches on fire, go to the nearest emergency shower immediately. If a shower is not available, then stop, drop, and roll. A fire extinguisher may be used to extinguish a fire on someone's person. Report any burn injuries to the supervisor immediately and seek medical treatment. Report to the EH&S within 8 hours every time a fire extinguisher is discharged.

Chemical Spills

Chemical spills can result in chemical exposures and contaminations. Chemical spills become emergencies when:

- The spill results in a release to the environment (e.g., sink or floor drain)
- The material or its hazards are unknown
- Laboratory staff cannot safety manage the hazard because the material is too hazardous or the quantity is too large

Effective emergency response to these situations is imperative to mitigate or minimize adverse reactions when chemical incidents occur.

All spills or unplanned release of a hazardous chemical, waste, or compressed gas must be reported immediately to Chapman University Public Safety who will immediately contact the Chapman University Environmental Health & SafetyManager and theAssociate Vice President of Risk Management. For the

Orange Campus

From a Chapman phone: extension 6763
From an outside line: (714) 997-6763

Irvine Campus

From a Chapman phone: 911 –
Follow up and contact Public Safety : extension 6763 or (714) 997-6763

- Notify everyone in the immediate area and the supervisor
- Evacuate personnel from the spill area
- Deny entry.
- Alert other building occupants. NOTE: Evacuation of the building and its occupants may be necessary depending on the volume of the material spilled and its relative hazard.

For further instruction follow the emergency response procedures, (Spill and Accident Procedures), which are posted in all classrooms and laboratories.

Chemical Spill Clean-Up

Chemical spill clean-up must not be attempted if the employee does not have the proper training and experience, the necessary spill kit supplies, and personal protective equipment must be provided. Contact Chapman University EH&S, or if not immediately available, Public Safety for any chemical spill clean-up.

Program Review and Approval

By unanimous vote, the March 2, 2009 Chemical Hygiene Plan was approved by the Chapman University Science Safety Committee under the Chair of Dr. Catherine D. Clark.

By unanimous vote, on May 16, 2014 amendments to the Chemical Hygiene Plan were approved by the Chapman University Science Safety Committee under the Chair of Dr. Justin O'Neill.

EH&S reviews the Plan on an annual basis, and the most recent review and modification was completed as on September 9, 2021.