Environment, Health and Safety
DIVISION OF FACILITIES PLANNING & MANAGEMENT
UNIVERSITY OF WISCONSIN–MADISON

## UW-Madison Campus

# Chemical Hygiene Plan and Policy

Department of Environment, Health & Safety
Office of Chemical Safety
August 2020

Table of Contents

# 1.0 Introduction

## 1.1 Purpose

The University of Wisconsin-Madison is committed to protecting employees from the health and physical hazards associated with chemicals in university laboratories. Every effort is made to ensure that risks, including those from hazardous chemicals, are mitigated to an acceptable level through appropriate engineering controls, specific procedures, and policies instituted by the university. While the UW-Madison administration has provided significant resources to ensure that the vital research performed is done in full compliance with applicable federal, state, and local regulations, the responsibility for ensuring a safe workplace must truly be a shared responsibility between faculty, staff, students, and campus environment, health and safety professionals.

The *UW-Madison Campus Chemical Hygiene Plan and Policy* (Campus CHP) was developed to maintain compliance with the OSHA Laboratory Standard. In addition to OSHA regulations, this document also presents key information on the practices and procedures that must be implemented to maintain compliance with other key state, federal, and local regulations required for the use and storage of hazardous chemicals.

## 1.2 Background on Regulatory Compliance

The Occupation Safety and Health Act of 1970 established the Occupational Safety and Health Administration (OSHA). The mission of OSHA is to save lives, prevent injuries, and protect the health of America's workers. Beginning in the early 1970s, a variety of groups and individuals representing laboratories contended that the existing OSHA standards were designed to protect workers from exposure conditions in industry and were inappropriate for the different exposure conditions in research laboratories. To correct this situation, OSHA developed a special regulatory section specific for laboratories. This standard, *Occupational Exposure to Hazardous Chemicals in Laboratories*, is often referred to as the OSHA Laboratory Standard (29 CFR 1910.1450). The Wisconsin Department of Safety and Professional Services has adopted the Laboratory Standard as part of its regulatory framework and therefore it applies to all state agencies and employees.

The requirements imposed by the OSHA Laboratory Standard include:

- Protecting employees from physical and health hazards associated with hazardous chemicals in laboratories;
- Keeping chemical exposures below specified limits;
- Training and informing workers of the hazards posed by the chemicals used in the laboratory;
- Providing for medical consultations and exams, as necessary;
- Preparing and maintaining a written safety plan (the Chemical Hygiene Plan);
- Designating personnel to manage chemical safety.

Other agencies, including the U.S. Environmental Protection Agency, the U.S. Department of Transportation, the Wisconsin Department of Natural Resources, the Wisconsin Department of Safety and Professional Services, and the Madison Fire Department, also impose obligations on users of hazardous chemicals, including:

- Specific storage requirements for hazardous chemicals;
- Limitations on the quantities of hazardous chemicals;
- Handling, storage, and disposal requirements for hazardous waste;
- Restrictions on the shipping and transporting of hazardous chemicals.

## 1.3 Chemical Hygiene Plan Overview

This document, in and of itself, is not sufficient to maintain compliance with OSHA regulations. The complete Chemical Hygiene Plan for each laboratory consists of three elements:

1. **The *UW-Madison Campus Chemical Hygiene Plan and Policy* (Campus CHP)**
   This document outlines roles and responsibilities for key personnel, contains policies and practices applicable to the entire campus, and provides an understanding of the applicability of various regulations to operations in a campus laboratory.
2. **The UW-Madison *Laboratory Safety Guide* (and other guidance documents)**
   The *Laboratory Safety Guide* is prepared by the Chemical Safety Office within the Environment, Health & Safety Department (EH&S). This contains a wealth of information including specific practices and procedures for the safe use and disposal of chemicals. The Chemical Safety office also provides guidance documents on specific topics. The *Laboratory Safety Guide*, along with the guidance documents, can be found at the EH&S website: www.ehs.wisc.edu
3. **The Laboratory-Specific Chemical Hygiene Plan (Laboratory CHP)**
   Each Principal Investigator must prepare a laboratory-specific Chemical Hygiene Plan that contains standard operating procedures (SOPs), personal protective equipment (PPE) requirements, engineering and administrative controls, and training prerequisites specific to their laboratory's operations.

   A template for a laboratory-specific CHP can be found on the EH&S website (www.ehs.wisc.edu). The template includes directions on how to complete each section. This template provides an organizational framework for ensuring that Principal Investigators are compliant with OSHA laboratory safety regulations. The Laboratory CHP template contains the following sections:

   Section 1: Personnel
   - Safety Personnel
   - Laboratory Staff and Students

   Section 2: Locations
   Section 3: Laboratory-specific Policies
   Section 4: Standard Operating Procedures
   Section 5: Orientation Checklist
   Section 6: Training

- Master List of Required Training
- Record of Training

Section 7: Prior Approvals
Section 8: Hazardous Chemical List/ Safety Data Sheets
Section 9: Exposure Monitoring Records
Section 10: References

## 1.4 Scope and Applicability

The Chemical Hygiene Plan (including the Campus CHP, Laboratory CHP and Laboratory Safety Guide) describes the necessary protection from risks posed by the laboratory use of hazardous chemicals and is limited to laboratory settings (where small amounts of hazardous chemicals are used on a laboratory-scale on a non-production basis). All campus laboratories must comply with the requirements outlined in this document. While certain organizations within or associated with the university have the option of adopting their own Chemical Hygiene Plans, those plans must, at a minimum, meet the elements outlined within this document and the laboratory-specific CHP template.

This plan does not specifically address protection needed against radiological, biological or other hazards (electrical, laser, mechanical, etc.), though elements of these may be covered in lab-specific SOPs. Questions on the applicability of this plan can be addressed to the Chemical Safety Office by calling 265-5700 or via email at chemsafety@fpm.wisc.edu. Information on chemical, biological, and radiological safety – as well as other safety topics – can also be found on the EH&S website: www.ehs.wisc.edu

## 1.5 Implementation of the Plan

The OSHA Laboratory Standard requires the designation of personnel responsible for implementation of the Chemical Hygiene Plan. Specifically, it calls for the assignment of a Chemical Hygiene Officer (CHO). The University of Wisconsin-Madison has assigned the role of Chemical Hygiene Officer to the head of the Chemical Safety Office, organizationally residing within EH&S. This individual has the responsibility for development and implementation of the Campus CHP and for ensuring overall compliance with all chemical safety regulations.

The CHO works with the UW-Madison Chemical Safety Committee (CSC) on the development of a campus-wide chemical safety and compliance program. The CSC approves this plan and aids in its implementation.

For laboratories on campus, the university designates the Principal Investigators as the individuals responsible for developing and implementing the Laboratory CHP for laboratories under their control. For some academic units that have developed departmental or organizational CHPs, the responsibility for developing and implementing a CHP has been designated as a departmental function and assigned to an individual or committee. Ultimate responsibility for compliance still resides with the Principal Investigator (or to an individual who has been assigned responsibility for a given laboratory). Academic units that have laboratories containing hazardous materials are encouraged to have their own safety officers to help implement their chemical hygiene plans.

## 1.6 Availability of the Plan

All elements of the Chemical Hygiene Plan (including the Campus CHP, Laboratory CHP and Laboratory Safety Guide) must be made readily available to employees or employee representatives.

## 1.7 Annual Review and Evaluation of Plan

The UW-Madison Chemical Hygiene Officer shall review and evaluate the effectiveness of the Campus CHP at least annually and update it as necessary. The university's Chemical Safety Committee will review and approve all changes to the plan. Updates to the CHP will be posted on the Chemical Safety Office website.

For a Laboratory CHP to be useful it must reflect the work that is currently performed within the laboratory. The Principal Investigator must formally review the Laboratory CHP at minimum annually to ensure that its contents are appropriate and adequate for current operations. If changes are necessary before the review date, the Laboratory CHP must be amended and the changes approved by the respective Principal Investigator.

## 2.0 Roles and Responsibilities

In order to maintain an effective chemical safety program, it is important for all parties to clearly understand the responsibilities inherent in their roles. Below are assigned roles and responsibilities that are necessary to remain compliant with chemical safety regulations.

For the purpose of this document, a Principal Investigator is any individual who has primary responsibility for the operations of assigned laboratory space. In most instances, this will be a UW-Madison faculty member. In some instances, a facility director or department chair may assign the responsibilities outlined in this plan to a member of the academic staff (e.g., a supervisor of an instrumentation laboratory can be considered a Principal Investigator for the purposes of this plan).

## 2.1 Director, Environment, Health & Safety Department

The Director of EH&S will provide the necessary staffing and resources for maintaining an effective Chemical Safety Program.

## 2.2 University Chemical Hygiene Officer

The university Chemical Hygiene Officer (CHO) has the primary responsibility for ensuring implementation of the Campus CHP and overall compliance with chemical safety regulations. The CHO will:

- Review and update the Campus CHP;
- Maintain and update the UW-Madison *Laboratory Safety Guide* and other guidance documents;
- Facilitate the campus community's understanding of, and compliance with, required chemical health and safety regulations;
- Provide technical guidance to Principal Investigators on the development and implementation of Laboratory CHPs;
- Provide guidance for the safe handling, storage, and disposal of chemicals used on campus;
- Facilitate waste minimization by redistributing surplus chemicals;
- Facilitate efforts to implement processes that are environmentally friendly;
- Provide the EH&S staffing resources necessary to ensure that activities related to the use of hazardous chemicals in campus laboratories are conducted in a safe manner.

### 2.3 Environment, Health & Safety Department (EH&S) Staff

Environment, Health & Safety Department staff have extensive expertise covering all areas of safety and compliance. EH&S personnel will:

- Develop, implement, and manage a comprehensive safety program for the university;
- Develop campus safety policies in conjunction with the appropriate campus faculty committees;
- Develop and prepare safety training specific to laboratory operations;
- Perform laboratory hazard assessments upon request;
- Inspect laboratories and identify hazards and issues of non-compliance;
- Inspect campus safety showers, eyewash stations, and fire extinguishers annually to ensure their proper operation;
- Coordinate campus chemical emergency response with the Madison Fire Department's Hazardous Incident Response Team;
- Maintain website containing easily accessible information, guidance, forms, etc.

### 2.4 Principal Investigator

The Principal Investigator has the primary responsibility for providing a safe work environment and for ensuring compliance with all elements of the Campus and Laboratory CHPs within their own assigned laboratory space. While the Principal Investigator can delegate health and safety responsibilities to a trained and knowledgeable individual (referred to as the Laboratory Chemical Hygiene Officer), the Principal Investigator must ultimately assure that the duties are performed. The Principal Investigator must:

- Develop and implement the Laboratory CHP;
- Approve SOPs, ensuring that PPE, engineering controls, and administrative controls described within the SOPs provide adequate protection to staff;
- Maintain compliance with federal, state, and local regulations related to the use of hazardous chemicals in their laboratory (as outlined in this document);
- Provide access to manufacturers' Safety Data Sheets (SDSs), the campus and laboratory CHPs, and other safety-related information for laboratory staff;
- Ensure that workers understand and follow the chemical safety policies, practices, and regulations related to their laboratory's operation;
- Assess individual roles of their staff and hazards associated with those roles;
- Ensure that PPE and required safety equipment are available and in working order and that laboratory staff is trained in their use;
- Determine training requirements for laboratory workers based on their duties and tasks and ensure appropriate training specific to laboratory operations has been provided;
- Ensure that staff is knowledgeable on emergency plans, including fires, equipment failure, chemical exposures, and chemical spills;
- Complete and keep the Laboratory Emergency Door Card up to date;
- Maintain up-to-date chemical inventories (minimum requirements are discussed in Section 6.3);
- Conduct regular chemical hygiene inspections and housekeeping inspections, including inspection of emergency equipment;
- Correct any unsafe conditions identified within the laboratory through either self-inspections or inspections by EH&S or other authorized safety professionals;
- Maintain documentation on training, exposure monitoring, approvals, and other safety related issues, as outlined in this document;
- Ensure proper disposal of hazardous materials according to university procedures;
- Contact EH&S on any lab-related injury or significant exposure;
- Submit accident reports to the Worker's Compensation Office within 24 hours of the incident.

## 2.5 Laboratory Personnel

The individuals working under the supervision of the Principal Investigator must:

- Follow campus and laboratory practices, policies, and SOPs and as outlined in the Campus and Laboratory CHPs;
- Attend all safety training as required by the Principal Investigator;
- Perform only procedures and operate only equipment that they have been authorized to use and trained to use safely;
- Check relevant information on the chemical reactivity and physical and toxicological properties of hazardous materials (such as Safety Data Sheets, *Prudent Practices in the Laboratory*, the *UW-Madison Laboratory Safety Guide,* and related articles found during a thorough literature search) prior to use of the chemical substance;

- Have knowledge of emergency procedures prior to working with hazardous chemicals;
- Incorporate safety in the planning of all experiments and procedures;
- Use the personal protective equipment and hazard control devices provided for his/her job;
- Routinely check that engineering controls are functioning;
- Ensure that equipment is safe and functional by inspection and preventative maintenance, including glassware, electrical wiring, mechanical systems, tubing and fittings, and high energy sources;
- Understand the inherent risk of any laboratory procedure;
- Report any unsafe condition immediately to the PI or other safety personnel;
- Keep work areas clean and orderly;
- Avoid behavior which could lead to injury;
- Dispose of hazardous waste according to university procedures;
- Report incidents involving chemical spills, exposures, work-related injuries, and illnesses or unsafe conditions to Principal Investigator;
- Consult with the Principal Investigator or with EH&S staff on any safety concerns or questions.

## 2.6 UW-Madison Chemical Safety Committee

The UW-Madison Chemical Safety Committee is comprised of university faculty and staff drawn from many organizations and departments. The Chemical Safety Committee will:

- Develop, review, and approve campus policies on issues related to the purchase, use, storage, and disposal of chemicals.
- Review compliance with campus policies and recommend methods to promote compliance.
- Review and approve, where necessary, the UW-Madison Campus Chemical Hygiene Plan, Hazard Communication Plan, Biennial Stormwater Report (to the WDNR), Pesticide Use Policy, and other university plans related to hazardous chemical use brought forth by the campus Chemical Hygiene Officer.
- Evaluate the broad needs for an effective campus-wide chemical safety program. Make recommendations to EH&S and, if necessary, to the campus administration, on such areas as staffing needs, funding sources, and required resources.
- Review incidents, accidents, and injuries related to the use of hazardous chemicals as reported by the campus Chemical Hygiene Officer and recommend additional corrective and preventative actions.
- Serve as a forum to review laboratory practices and procedures to ensure that these are compatible for the protection of the environment. Promote methods and procedures to minimize production of hazardous waste and prevent pollution from research, maintenance, patient care, teaching and other

university activities.

- Collaborate with other committees, including but not limited to the Occupational Health Committee, the Biological Safety Committee, the Animal Care and Use Committee, the various Radiation Safety Committees, and the Institutional Review Boards to assure that chemical safety concerns are properly addressed.

## 3.0 General Laboratory Rules and Policies

The UW-Madison Chemical Safety Committee has the ability to develop, review, and approve campus policies on issues related to the purchase, use, storage, and disposal of chemicals. All university personnel are subject to these policies in addition to federal state, and local regulations and codes.

Each Principal Investigator has the right to set polices for laboratories under their control as long as these are, at a minimum, compliant with regulations and campus-wide policies. Laboratory specific policies should be included in the Laboratory CHP.

The following general policies apply for all laboratory operations involving hazardous chemicals:

> *It is university policy* that appropriate PPE must be worn at all times. At a minimum, close-toed shoes and safety glasses must be worn whenever hazardous chemicals are present in the laboratory.
>
> *It is university policy* that no eating and drinking is allowed in laboratories where hazardous chemicals are present.
>
> *It is university policy* that unnecessary exposure to hazardous chemicals via any route will be avoided through proper use of engineering controls, personal protective equipment, and administrative controls.
>
> *It is university policy that the use of audio headphones (over-ear and in-ear)* is prohibited when performing chemical procedures and highly hazardous operations.
>
> *It is university policy* that good housekeeping practices be upheld in all laboratories and that all passageways, exits, utility controls, and emergency equipment remain accessible at all times.
>
> *It is university policy* that any procedure or operation identified by laboratory or EH&S staff as imminently dangerous (i.e., the operation puts individuals at immediate serious risk of death or serious physical harm) must be immediately stopped until corrective action is taken.

Additional specific policies for use of high-hazard compressed gases and for the use of cryogenic liquids are found in **Appendix A** of this plan. The *Laboratory Safety Guide* also provides general laboratory safety rules as well as recommendations for safe work practices. Additional university policies are outlined in subsequent sections of this plan.

## 4.0 Hazardous Chemical Identification and Control

### 4.1 Risk Assessments

Many chemicals can cause immediate health problems as well as long-term health effects. Examples include carcinogens, toxic or highly toxic agents, reproductive toxins, irritants, corrosives, sensitizers, hepatotoxins, nephrotoxins, neurotoxins, agents which act on the hematopoietic system, and agents which damage the lungs, skin, eyes, or mucous membranes. Hazardous chemicals (such as flammable and combustible liquids, compressed gases, and unstable and water-reactive materials) can also pose inherent physical dangers. The University of Wisconsin is committed to minimizing worker exposure to the hazards imparted by use of hazardous chemicals and takes a risk-based approach in determining means of mitigating risk taking into account the characteristics of the chemical, the amounts used, the method in which a chemical is used, and the location.

The university requires that each Principal Investigator review all operations involving laboratory use of hazardous chemicals. Whenever possible the hazard should be eliminated or substitution of a hazardous chemical or procedure with a substance or process with lower inherent risk should be undertaken. Additionally, control measures commensurate with the risk must be implemented. Control measures include engineering controls (such as fume hoods, glove boxes, or intrinsically), administrative controls (such as policies against working alone), and personal protective equipment (gloves, eye protection, respirators, etc.). EH&S provides tools to perform this risk assessment, including the *Laboratory Safety Guide* and other guidance documents. Additionally, EH&S staff can provide consultation services if there are any questions on this process.

### 4.2 Exposure Limits

It is the responsibility of the Principal Investigator to insure that laboratory staff members have knowledge of the exposure limits applicable to the chemicals that are used within the lab. OSHA has the regulatory authority to set specific air exposure limits for chemicals. These Permissible Exposure Limits (PELs) are listed in 29 CFR 1910.1000 TABLE Z-1. States have the right to impose more stringent requirements and the State of Wisconsin has done so for public employees as outlined in Chapter SPS 332 "*Public Employee Safety and Health.*" In lieu of 29 CFR 1910.1000, July 1, 2003 edition, an employee's exposure to air contaminants is regulated by the July 1, 1992 edition of 29 CFR 1910.1000. This earlier version is more stringent since it sets PELs for substances not in the later version and includes Short Term Exposure Limits (STEL) to complement 8-hour time weighted average (TWA) limits, establishes skin designations, and adds ceiling limits as appropriate. (Note: The 1992 edition of 29 CFR 1910.1000 was struck down by the courts and is not enforceable by federal OSHA.)

For substances that do not have an exposure limit specified in the OSHA standards, SPS 332 states that it will accept the recommendations of the American Conference of Governmental Industrial Hygienists (ACGIH) for Threshold Limit Values (TLVs).

While the published PELs and TLVs are enforceable, they were not created with a university laboratory setting in mind. The published ACGIH exposure limits, like the PELs, are levels to which it is believed nearly all workers may be exposed during a 40-hour workweek over a working lifetime without harmful effects. Most laboratory workers perform non-routine operations over a short time span. In these instances short-term exposure limits are often more appropriate. Many chemicals do not have any published exposure limits. It is the university's policy, therefore, that all prudent steps will be taken to reduce exposures beyond what is legally required or, when there is no legal requirement, to minimize exposure by reasonable actions. See **Appendix B** for information on finding and interpreting OSHA PELs and ACGIH TLVs.

## 4.3 Engineering Controls

As stated above, a primary goal of chemical safety efforts is to minimize the potential for exposures. A direct way of reducing exposure can be accomplished by isolating the source or removing contaminants through various ventilation methods. Engineering controls should be implemented within the laboratory whenever practical to minimize exposure to hazardous chemicals.

By far the most commonly used engineering control used in laboratories is the chemical fume hood. Fume hoods are especially effective when handling gases, vapors, or powders. Laboratory workers rely heavily on these, often while performing the most hazardous tasks. Section 4.4 of the *Laboratory Safety Guide* provides information on the proper us of fume hoods.

Due to the importance placed on fume hoods some key requirements are emphasized below:

- Laboratory workers must understand how to properly use chemical fume hoods. Principal Investigators need to ensure that workers have received the proper training, and document that training for laboratory safety records.
- Details of chemical fume hood use, maintenance, and annual testing can be found in the UW-Madison *Laboratory Safety Guide* under the "Fume hoods and other Engineering Controls" heading. Additionally, a training module (entitled "Fume Hood Use") is available online through Learn@UW.
- Fume hood inspection, testing, and maintenance are performed annually by the UW-Madison Facilities Planning & Management (FP&M) Physical Plant. After inspection, a certification sticker is affixed to each fume hood, which lists the most recent certification date. Fume hoods with a certification date

greater than one year must be put out of service until recertification is complete (if fume hood inspection date is more than one year old, contact FP&M Physical Plant Customer Service (PPCS) for recertification at 263-3333).

- Fume hoods must be tested prior to any hazardous operations. In many instances, fume hoods are alarmed and provide an audible warning when the airflow is outside normal parameters. If the fume hoods are not working properly in the laboratory, chemicals in the hood should be secured and the work stopped. Contact FP&M PPCS at 263-3333 if any issues with the fume hoods have been detected.
- Working with perchloric acid poses a unique risk due to the possible buildup of potentially explosive perchlorate residues on surfaces and in duct work. For this reason special fume hoods with a water wash down system have been designed for use with perchloric acid. A specially designated perchloric acid fume hood must be used if any of the following is applicable:
  - Concentrated perchloric acid (60% or greater) is used;
  - Perchloric acid (at any concentration) is used at elevated temperatures;
  - Perchloric acid is used under conditions where it may become concentrated (such as with strong dehydrating agents).

  The wash down system should be used after each operation.
- Fume hood alarms should never be disarmed without first consulting with the Chemical Safety Office and contacting CARS.

Other ventilation methods, including general room ventilation, point-source (such as snorkels), and gas cabinets also provide protection to workers. Glove boxes, glove bags, pressure relief valves, automatic shut-offs, and air monitors are also routinely used on campus.

Due to the reliance placed on these engineering controls, laboratory personnel need to incorporate regular inspections and/or testing of the controls into their standard operating procedures to ensure proper operation. This may be as simple as testing that air is flowing or gauges are working. Some controls are more complicated and may require routine maintenance or calibration by outside vendors.

### 4.4 Administrative Controls

Administrative controls consist of policies and procedures developed to improve the safety of laboratory operations. Typical examples include night-time work hour limitations and experimental scale-up restrictions. Since administrative controls require lab personnel to follow appropriate procedures these are generally not as reliable as engineering controls. While the University of Wisconsin-Madison Chemical Safety Committee sets broad campus policy, as outlined in this document, it does not set specific administrative controls for use of hazardous chemicals. These controls must be set by individual PIs or Departments. If not already documented in departmental safety plans, administrative controls should be documented in the policy section of the laboratory-specific CHP or within an SOP for procedure-specific controls. All laboratory staff needs to be informed of these controls.

### 4.5 Personal Protective Equipment (PPE)

Engineering and administrative controls are the primary lines of defense within the hierarchy of hazard minimization. When these methods are not adequate then exposure to hazardous chemicals can normally be minimized, if not eliminated, through proper selection of PPE. Typical examples of PPE include safety goggles, safety glasses, lab coat, gloves, and respirators. The Principal Investigator has the primary responsibility to determine the appropriate PPE and ensure that the PPE is made available. Details are important. If respirators are required, specific types of respirators must be indicated. The same is true for gloves – chemical compatibility plays a major role in determining the type of glove (e.g., latex, nitrile, vinyl). The *Laboratory Safety Guide* provides guidance on PPE choices. Additional information can be found on Safety Data Sheets, which often provide information on the proper choice. The Chemical Safety Office can provide assistance on proper choice for PPE. The Environmental & Occupational Health office should be contacted at eoh@uhs.wisc.edu to assist in the proper selection, training, and use of respirators.
While close-toed shoes and safety glasses are the minimum PPE requirements for all laboratories containing hazardous chemicals, the PPE required for specific procedures and tasks should be reflected in the Laboratory CHP. The Standard Operating Procedure (SOP) templates available on the EH&S Chemical Safety Office website provide a means to document the requirements.

University Health Services (UHS) provides prescription safety glasses if required to perform your work. The safety glasses provide frontal protection only from such hazards as flying particles encountered in woodworking, machine metalwork, general warehouse, stock clerk, dock work, brush cleaning, etc. Side shields, which are necessary for side protection from flying particles, are available with the glasses. These do not provide adequate eye and face protection from chemical splashes or fumes. Contact UHS at 890-1051 if you need additional information on this service. Information can also be obtained at their website: https://www.uhs.wisc.edu/eoh/workplace-hazards/eyewear/

### 4.6 Safety Showers, Eyewashes, and Fire Extinguishers

Safety showers and eyewashes are essential protective elements for laboratories. Wisconsin Administrative Code SPS 332.30 states, “Whenever the eyes or body of any person may be exposed to materials that are corrosive or can cause irreversible eye or bodily injury, suitable facilities for quick drenching or flushing of the eyes and body shall be provided within the work area for immediate emergency use.” The Wisconsin code also notes that it will accept facilities that comply with ANSI standard Z358.1, *Emergency Eyewash and Shower Equipment*.

The ANSI Z358.1 has some specific requirements for safety showers and eyewashes. According to this standard emergency eyewashes and showers:

- Must be located within 10 seconds travel time or 55 feet of travel distance of the hazard and shall be located on the same level as the hazard and the path shall be free of obstructions;
- Must be in good working order and meet ANSI performance specifications;
- Shall be tested weekly (applicable to eyewashes) to verify proper operation and shall be inspected annually to assure conformance with requirements;
- Shall be identified with highly visible signs.

Employees must be instructed in the location and proper use of the equipment. Personal eyewash equipment such as a drench hoses may support but not replace approved eyewashes and showers.

Safety showers and eyewashes are inspected annually by Environment, Health & Safety. Contact Environment, Health & Safety at 265-5000 if your safety shower, eyewash or drench hose has not been inspected or if you any questions concerning the requirements for eyewashes and safety showers.

EH&S Fire Safety section manages over 12,000 extinguishers on the University of Wisconsin campus. This group provides, installs, and inspects all necessary fire extinguishers. It also provides training on proper use of extinguishers. While the fire extinguishers provided work for most situations, specific laboratory operations (e.g., those involving flammable metals) may require special extinguishers. The EH&S Fire Safety website has additional information at https://ehs.wisc.edu/fire-safety/ .

### 4.7 Particularly Hazardous Substances (PHSs)

OSHA regulations require that provisions for additional employee protection be made for work with particularly hazardous substances (PHSs). These include carcinogens, reproductive toxins, and substances that have a high degree of acute toxicity. As part of the required risk assessment for any work involving hazardous materials, all PHSs must be identified by the Principal Investigator or laboratory worker designing the experiment or procedure. (Note: see **Appendix C** for more information on PHSs). Use of any PHS requires:

- Establishment of a designated area;
- Use of appropriate containment devices such as fume hoods or glove boxes;
- Procedures for safe removal of contaminated waste;
- Decontamination procedures.

The room or area where work with PHS is performed must be posted with a ***Designated Area*** sign; sign samples in MS Word and PDF formats can be found on the EH&S Chemical Safety website. The posting of an established "designated area" identifies areas of higher health risk. In many laboratories, it is appropriate to establish the entire room as a "designated area" whereas in other laboratories a workbench or fume hood is more appropriate.

The controls used to minimize exposures to PHSs must be documented in the Laboratory CHP. The Standard Operating Procedure (SOP) templates found in the Laboratory CHP template provide a means to document the controls.

## 4.8 Prior Approvals

The nature of the work performed in laboratories on campus varies widely. Principal Investigators must ensure that a risk assessment is performed for all activities involving hazardous substances. Certain procedures may be considered hazardous enough that these should only be performed with prior approval of the Principal Investigator. While typically these may involve work with PHSs, other procedures, such as those involving pyrophoric, highly reactive or flammable compounds, may appropriately fall within this category.

The University of Wisconsin-Madison allows the Principal Investigator to make the determination if a procedure needs prior approval. The Standard Operating Procedure (SOP) templates available on the EH&S website provide a means to document whether a specific procedure requires prior approval. Additionally, within the Laboratory CHP a section has been devoted to documentation of approvals.

## 5.0 Hazard Communication

One of the key requirements in OSHA chemical safety regulations is the communication of the potential hazards to which a worker may be exposed. This section describes UW-Madison policies for meeting these requirements.

## 5.1 Chemical Hygiene Plans

OSHA regulations require the development of a Chemical Hygiene Plan which sets forth procedures, equipment, personal protective equipment and work practices that are capable of protecting employees from the health and physical hazards presented by hazardous chemicals used in that particular workplace. The Campus CHP and *Laboratory Safety Guide* meet many of the requirements. However, work practices are laboratory specific and the university requires that Principal Investigators prepare the Laboratory CHP in order to be in full compliance. Additionally, the entire CHP (including the Campus CHP, the Laboratory CHP, and the *Laboratory Safety Guide*) must be readily available to laboratory workers and worker representatives. These documents should be placed in a location that readily accessible to all workers or made available electronically (such as on a network drive).

## 5.2 Safety Data Sheets and Other Safety Information

A Safety Data Sheet (SDS) is prepared by manufacturers and summarizes the physical and chemical characteristics, health and safety information, handling, and emergency response recommendations related to their products. An SDS should be reviewed before beginning work with a chemical in order to determine proper use and safety precautions.

OSHA regulations require that once a chemical is present in the laboratory the SDS must be made available, either electronically or as a hardcopy. Personnel must have ready access for reference in the case of emergencies. The International Fire Code (IFC), which has been adopted by the Madison Fire Department (MFD), also states that SDSs shall be readily available on the premises.

SDSs alone may not provide sufficient information on the hazards of a chemical. Laboratory personnel should review other sources of information on the chemical, such as the chemical literature or references on safe handling of chemicals such as National Research Council's *Prudent Practices in the Laboratory*. These resources should be made available to laboratory staff.

### 5.3 Exposure Monitoring Results

In certain instances UW EH&S or the Environmental & Occupational Health Program at University Health Services may measure laboratory worker exposure to a chemical regulated by a standard. The Principal Investigator must, within 15 working days after the receipt of any monitoring results, notify the laboratory staff of these results in writing either individually or by posting results in an appropriate location that is accessible to employees. A section of the Laboratory CHP has also been delegated to the documentation of these results. Additional information on exposure monitoring is provided in Section 13.0.

### 5.4 Labeling Chemical Containers

Chemicals received from outside vendors are, by law, required to have labels indicating the chemical identity and common name, manufacturer name, address and phone number, pictograms, signal words, hazards statements, and precautionary statement. Manufacturers' labels on chemical containers shall not be removed or defaced.

Frequently, chemicals are dispensed from the original shipping container to a smaller container or chemical mixtures are prepared for subsequent use. All secondary containers must be labeled with the following information:

- The chemical name;
- The primary hazard(s);

The primary hazards can be presented either in the form of GHS pictograms, GHS hazard statements, the NFPA 704 Standard ("Standard System for the Identification of the Hazards of Materials for Emergency Response", commonly referred to as the NFPA fire diamond), or other similar hazard identification system. All lab personnel must be trained in the hazard communication method that is employed.
It is acceptable to use one label for a rack containing individual vials of similar chemicals.

### 5.5 Laboratory Emergency Information Cards

It is not only necessary to provide workers with awareness of the hazardous chemicals present in a laboratory, but this information must also be provided to first responders in the event of an emergency. The Madison Fire Department (MFD) relies on the Laboratory Emergency Information Cards (i.e., the yellow "door cards") to provide valuable information and these cards are required by fire code. Emergency responders need to know the hazards before entering a laboratory. EH&S requires that the cards be, at a minimum, reviewed annually and updated in the event of any change in the information. Door cards can be obtained by contacting EH&S at 265-5000. Additional information can be obtained at:
http://www.ehs.wisc.edu/laboratory-emergency-door-cards.htm

## 6.0 Chemical Storage and Inventory

Use and storage of hazardous chemicals is regulated by federal, state, and local regulations. These regulations include OSHA worker protection standards, emergency response and planning regulations and local building and fire codes. Each of these place limitations on how much materials can be used, where they can be used or stored, or require information on inventory to be available for emergency planning and response.

## 6.1 Chemical Storage and Use Limits

The university must meet the requirements outlined in International Fire Code (IFC), by virtue of its adoption by the Madison Fire Department (MFD) – subject to modification as described in the City of Madison Fire Prevention Code. MFD also enforces sections of the National Fire Protection Association (NFPA) standards since these have been adopted by IFC reference. Finally, OSHA 29 CFR 1910.106 "*Flammable and Combustible Liquids*" is also enforceable. Together, these place limitations on use and storage of compressed gases, cryogenic fluids, highly toxic and toxic materials, flammable and combustible liquids, and water reactive solids, to name a few. The Madison Fire Department performs routine inspections of buildings and has the authority to cite any situation that they deem in violation of the relevant codes.

The allowable quantities (both in use and in storage) per 2015 IFC are presented in tables found in **Appendix D**. Allowable quantities are based on control areas, defined as "spaces within a building which are enclosed and bounded by exterior walls, fire walls, fire separation assemblies and roofs, or a combination thereof, where quantities of hazardous materials not exceeding the exempt amounts are stored, dispensed, used or handled." Although the code limits appear straightforward, application of the code can be more complicated due to the following:

- While quantities are based on control areas, these may consist of more than one laboratory and the boundary of a control area is not obvious;
- Building features, such as the presence of sprinklers, can affect the allowable quantities;
- The quantities allowed are also dependent on the specific floor the laboratory is located. Generally, the higher the floor level the lower the allowable

quantity per control area. Also the number of allowable control areas decrease the higher the floor level;

Due to the complexities of the standards and the university's need to remain compliant with these regulations *it is the university's policy that every effort be made to minimize the quantity of hazardous chemicals within the campus laboratories*.

In addition to the IFC limits, other limitations to storage and use apply. Below are some of the key policies and code requirements for storage of chemicals at UW-Madison. This list is not comprehensive and does not include many of the prudent safety practices included in Laboratory Safety Guide or the guidance documents found on the Chemical Safety Office website (www.chemsafety.wisc.edu ).

**Flammable Liquids:**
In addition to the IFC code requirements, the following university limits have been set (in instances in which the building limits are more stringent, those limits will apply):

- No more than ten (10) gallons of flammable liquids per typical laboratory may be stored outside a flammable storage cabinet (with the exception of materials stored in approved safety cans). Exception can be made by the Chemical Safety Office for larger laboratory suites, though this cannot exceed fire code limits;
- Further limitations are placed on the quantities that can be placed in an individual container based on the type of container (glass, metal, etc.). See Table D3 in **Appendix D**;
- Flammable liquids, if they need to be refrigerated, must be stored in laboratory-safe refrigerators. All the electrical components in this type of refrigerator are outside the refrigerator. UL-approved laboratory–safe refrigerators can be purchased from a variety of vendors. Refrigerators that are not laboratory-safe can be altered if modifications and signage in NFPA 45 *Standard on Fire Protection for Laboratories Using Chemicals* are used but modifications must be performed by a trained electrician. Contact the Chemical Safety Office for more information.

**Compressed Gas Cylinders:**
Below are a few general requirements for gas cylinder usage. Additional requirements for safe handling of gas cylinders can be found on the Chemical Safety Office website. Due to the hazards posed by highly toxic, corrosive, and pyrophoric gases all procedures involving these gases must be reviewed by EH&S staff prior to use (see Appendix A for details concerning the campus compressed gas policy). In order to ensure safe use and storage, all gas cylinders must be:

- Stored within a well-ventilated area, away from damp areas, salts or corrosive atmospheres, and away from exit routes;
- Stored in an upright position with full cylinders separated from empty cylinders;

- Secured with a chain or appropriate belt above the midpoint but below the shoulder. Laboratory cylinders less than 18” tall may be secured by approved stands or wall brackets;
- Capped when not in use or attached to a system (if the cylinder will accept a cap);
- Kept at least 20 ft. away from all flammable, combustible or incompatible substances. Storage areas that have a noncombustible wall at least 5 ft. in height and with a fire resistance rating of at least 30 minutes may be used to segregate gases of different hazard classes in close proximity to each other;

**Cryogenic Liquids:**

- Storage areas for stationary or portable containers of cryogenic liquids in any quantity must be stored in areas with adequate mechanical ventilation or natural ventilation. If it can be demonstrated that there is no risk of oxygen depletion or harmful vapors then ventilation is not required upon EH&S approval.
- Indoor areas where cryogenic liquids in any quantity are dispensed must be ventilated in a manner that captures any vapor at the point of generation. If it can be demonstrated that there is no risk of oxygen depletion or harmful vapors then ventilation is not required upon EH&S approval.
- If a review of cryogenic usage indicates that there is a possibility of creating a hazardous situation then additional signage, ventilation, and monitoring may be required. See Appendix A for additional information on the campus cryogenic liquid policy.

More comprehensive guidance can be found in the *Laboratory Safety Guide* and other documents on the Chemical Safety website or by contacting the Chemical Safety Office at 265-5700.

## 6.2 Chemical Compatibility and Safe Storage

In addition to chemical storage limitations imposed by regulations and codes, the Principal Investigator is responsible for following prudent storage practices of chemicals. This includes separating incompatible chemicals and disposing of unstable compounds (such as peroxide formers) after their indicated expiration date. Chemicals must be grouped according to their hazard category (i.e. strong acids, strong bases, oxidizers, flammables, pyrophorics, self-reactives, etc.). Chapter 4 and Appendix F of the *Laboratory Safety Guide* outline the principles that need to be followed.

## 6.3 Chemical Inventories

As stated throughout this document, the university is subject to numerous regulations above and beyond the OSHA Laboratory Standard. Below are some of the codes and regulations requiring that laboratory staff have knowledge of their chemical inventories:

### Emergency Planning and Community Right-to Know Act (EPCRA)

EPCRA is a federal statute that requires all entities that store, use or process hazardous chemicals to report this information to the State Emergency Response Commission and Local Emergency Planning Committees and in some cases the local fire department. EPCRA has four major provisions which are largely independent of each other and involve different chemical lists with different threshold reporting quantities.

**Department of Homeland Security (DHS) Chemicals of Interest**

The DHS has issued regulations related to security of high risk chemical facilities. These regulations, released in 2007, require facilities to determine if they have specific chemicals above screening threshold quantities. 300 chemicals (and respective thresholds) were identified. While most of the thresholds were set at thousands of pounds, some of the threshold amounts were significantly lower. The university completed the initial security screening but must report any change to DHS.

**Madison Fire Codes**

The Madison Fire Department requires entities that use hazardous materials to maintain inventories and to provide them upon request.

*While maintaining a complete inventory of chemicals is highly recommended (it prevents unnecessary purchases and reduces inventory),* ***at a minimum****, Principal Investigators must maintain an up-to-date chemical inventory for the following:*

- All quantities of Class IA flammable liquids;
- Class IB and IC flammable liquids greater than 100 milliliters;
- Water reactive chemicals in quantities greater than 50 grams;
- All organic peroxides, unstable compounds, and pyrophoric compounds;
- All gas cylinders;
- Highly toxic materials greater than 50 grams;
- Corrosive liquids greater than 2 liters;
- All EPCRA extremely hazardous substances listed in Appendix E;
- All DHS Chemicals of Interest listed in Appendix E.

Appendices B and C have information that would be useful in determining whether a chemical would fall under the inventory requirement. NFPA fire diamond information commonly available can also help. Liquids with a flammability rating of 3 are considered Class IB and IC liquids while those with a flammability rating of 4 are Class IA. If in doubt whether a chemical would fall under one of the above categories, then maintain it on your inventory. Inventories must be made available to the Chemical Safety Office upon request.

## 7.0 Chemicals and Drugs Used to Elicit a Biological Response

Use of FDA-approved drugs or experimental drugs in a clinical setting is outside the purview of this document. However, the safe handling and use of drugs in a laboratory setting must be described in the lab-specific CHP if the drug has the characteristics of a hazardous chemical or is a carcinogen and is in a form that has the potential to lead to an exposure. More broadly, *usage of any hazardous chemical for the purpose of eliciting a biological response must be covered by the Laboratory CHP.*

For animal experiments involving hazardous chemicals, it is the responsibility of the Principal Investigator to provide hazard communication information to animal care staff. This information will include, at a minimum:

- Identity of the chemical;
- Hazards associated with the chemical;
- Means that one should take to minimize exposure, including PPE and engineering controls;
- Location of SDSs;
- First aid response in the event of an exposure.

## 8.0 Biological Toxins

The *Public Health Security and Bioterrorism Preparedness and Response Act of 2002, Subtitle A of Public Law 107–188* requires the Department of Health and Human Services (HHS) to establish and regulate a list of biological toxins (and biological agents) that have the potential to pose a severe threat to public health and safety. The biological toxins, listed in the table below, are regulated if inventory levels exceed – at any time – the amounts indicated. Users that anticipate exceeding the listed thresholds must register with the university's Select Agent Program. Users who maintain quantities below the listed threshold are still required to maintain inventory logs containing the date of access, name of individual accessing the toxin, the quantity used, the purpose of use and the amount remaining. The toxins must be kept in a locked area with access limited to those who need it. The biological inventory logs must be sent on a quarterly basis to the Select Agent Program Manager. Unregistered individuals exceeding these limits face severe federal penalties. Use of biological toxins must also be included in biosafety protocols.

| **HHS Toxins [§73.3(d)(3)]** | **Amount** |
|---|---|
| Abrin | 100 mg |
| Botulinum neurotoxins | 0.5 mg |
| Short, paralytic alpha conotoxins | 100 mg |
| Diacetoxyscirpenol (DAS) | 1000 mg |
| Ricin | 100 mg |
| Saxitoxin | 100 mg |
| Staphylococcal Enterotoxins (Subtypes A, B, C, D, and E) | 5 mg |
| T-2 toxin | 1000 mg |
| Tetrodotoxin | 100 mg |

Questions concerning biological toxins should be directed to the Select Agent Responsible Official. https://ehs.wisc.edu/select-agent-team/

## 9.0 Drug Enforcement Agency (DEA) Scheduled Drugs

The Congress of the United States enacted into law the Controlled Substances Act (CSA) as Title II of the Comprehensive Drug Abuse Prevention and Control Act of 1970. Use of controlled substances in animal research is common in animal research where pain medication is required.

Use of controlled substances for research requires obtaining both federal (DEA) and state (WI Controlled Substances Board Special Use Authorization) registration. Penalties for using such drugs without proper registration can be severe. The regulations strictly limit who can handle or administer the drugs and imposes both physical security requirements as well as inventory requirements. Some key points concerning the regulations:

- The permitting process is between an individual researcher and the DEA and State;
- Registrants cannot share controlled substances with non-registered users who are not under their supervision (e.g., another research laboratory in their department);
- Possession of expired drugs also poses a risk to researchers from the USDA since administration of expired controlled substances is not allowed;
- Disposal is also strictly regulated. Only the DEA Special Agent in Charge can authorize the disposal of controlled substances.

EH&S has no role in the permitting process, though it can provide limited guidance upon request. Sewer disposal of any DEA drug is no longer an acceptable option. Contact the Chemical Safety Office for questions concerning disposal.

The University of Wisconsin Systems has very good guidance on the use of controlled substances. This can be found on their website: https://www.wisconsin.edu/ehs/hazmat/dea-substances/

## 10.0 Surplus Chemicals and Hazardous Waste

The Resource Conservation and Recovery Act (RCRA), enacted in 1976, is the principal Federal law in the United States governing the disposal of hazardous waste. RCRA is administered by the U.S. Environmental Protection Agency (EPA). In Wisconsin the hazardous waste regulations are found in Chapter NR 662 "*Hazardous Waste Generator Standards.*"

The university strives to maintain compliance with all regulations regarding hazardous wastes while at the same time minimizing waste by a number of programs. Our waste minimization efforts include chemical redistribution and inventory reduction programs.

### 10.1 On-Site Hazardous Materials Management (OSHMM)

The Chemical Safety Office operates the university's On-Site Hazardous Materials Management (OSHMM) program. Through the OSHMM program, Chemical Safety Office staff will come directly to laboratories to remove those items that can be redistributed, require a more complex disposal procedure, or require disposal at a commercial hazardous waste treatment, storage and disposal facility. Most materials picked up through OSHMM are considered to be surplus chemicals and are not designated as waste until EH&S Waste Management staff has made this determination. The main exceptions are the materials placed in the waste solvent carboys as well as used silica gel (commonly used for chromatography). These materials are considered hazardous waste at the time of generation.

The Chemical Safety website provides detailed information on how to request a chemical pick-up, the documentation that needs to be completed prior to the pick-up, and how materials should be packaged for pick-up. *The Chemical Safety Office highly recommends that laboratory staff periodically review their inventories and that requests for pick-up of unwanted chemicals be made on a frequent basis.*

## 10.2 In-Lab Chemical Management

As part of the chemical disposal process, Principal Investigators and laboratory staff are allowed to perform In-Lab Chemical Management of their inventories. In-Lab Chemical Management includes simple disposal and treatment methods that can be done in a lab, such as solvent commingling, flushing down the sanitary sewer (for non-hazardous chemicals), and neutralization. Approved disposal procedures are described in detail in UW *Laboratory Safety Guide*. The UW Chemical Safety Office gives advice regarding the disposal of specific chemicals and wastes and, in some cases, can demonstrate treatment and neutralization procedures. Follow the chemical disposal procedures in Chapter 7 and **Appendix A** of the *Laboratory Safety Guide*, including the In-Lab Chemical Management Procedures.

### Sanitary Sewer Disposal

The EPA does not allow the University of Wisconsin to sewer hazardous waste. Hazardous waste is usually classified as belonging to one of two groups: (1) characteristic hazardous waste (ignitable, corrosive, reactive or toxic) or (2) listed hazardous waste (K, F, P, U are the four lists published by EPA). However, the university is able to perform elementary neutralizations and dispose of the product in the sanitary sewer and sewer disposal of non-hazardous chemicals by complying with the Madison Metropolitan Sewerage District's (MMSD) and the university's agreed criteria for the environmentally sound disposal of laboratory chemicals.

It is essential that materials being sewered are water soluble and completely dissolved before going into the sink drain. Madison Metro Sewerage District ordinances emphasize that materials that damage the pipes (corrosive), create an unsafe atmosphere (ignitable or toxic) in the line access points, block flow or interfere with the treatment process are prohibited. The *Laboratory Safety Guide* provides information on sewer disposal of materials. Contact the Chemical Safety Office for specific questions.

**Satellite Accumulation Areas**

Federal regulations allow a waste generator to accumulate as much as 55 gallons of non-acute hazardous waste or one quart of acutely hazardous waste in containers at or near any point of generation and under the control of the operator. These storage locations are referred to as "Satellite Accumulation Areas" or SAAs and each laboratory is allowed one SAA. Requirements for laboratories maintaining SAAs include the following:

- The regulations impose no limit on the amount of time waste can be accumulated. However, once the 55 gallon container limit is met, the laboratory staff has 72 hours to have the container transferred to the university's hazardous waste storage area.
- Containers must be marked either with the words "Hazardous Waste" along with other words that identify the contents of the containers. ***It is especially important that containers holding waste mixtures, such as carboys, be labeled with the contents to prevent unexpected reactions which can lead to explosions or release of toxic gases.***
- Containers must be kept closed, except when adding/removing waste and must be handled in a manner that avoids ruptures and leaks.
- Closures (screw caps, bungs) must be air and liquid tight. Ensure that the caps provide the appropriate seal between the container rim and the cap liner.
- Personnel who generate waste or work in satellite accumulation areas need to be trained in waste handling and management, emergency procedures and other topics specific to that area. Typically this level of training is laboratory-specific and should be held in conjunction with other required training (see the Laboratory CHP template).

The Chemical Safety Office distributes 5-gallon carboys for organic solvent waste free of charge and picks these up once filled or no longer needed. Non-halogenated solvent waste must be collected separately from halogenated waste. While 55 gallons are allowed per SAA other regulations, such as the fire codes, may impose further limits on the number of carboys that can be stored in the laboratory.

## 10.3 Laboratory Cleanouts and Clean Sweeps

The Chemical Safety Waste Management group will perform laboratory cleanouts and departmental clean sweeps upon request. Clean sweeps provide opportunities for old and expired chemicals that may pose unnecessary risk to be removed. Information on cleanouts and moves can be obtained on the EH&S website.
For moves: https://ehs.wisc.edu/laboratory-move-guidelines/
For cleanouts: https://ehs.wisc.edu/lab-clean-outs/

## 10.4 Surplus Chemical Redistribution

The UW-Madison Chemical Redistribution Program tries to reduce the volume of unused chemicals being disposed as waste. The Chemical Safety Office will deliver these surplus chemicals to your laboratory for free. After surplus chemicals are collected a chemist examines them to determine that they are not degraded and are still useful for research. If so, the Chemical Safety Office will redistribute such chemicals to another campus laboratory upon request. All redistributed chemicals are in their original manufacturer's container. In many cases, these surplus chemicals still have the manufacturer's seals. Principal Investigators should review their inventory regularly and have their surplus chemicals picked up by EH&S so that these can be made available for use by other laboratories.

There are several ways to obtain surplus chemicals. The Chemical Safety Office provides an updated list of redistributable chemicals on the EH&S website:
https://ehs.wisc.edu/chemical-redistribution/
The same site can be used to submit an electronic request. Orders will be delivered directly to your facility.

## 11.0 Employee Information and Training

The OSHA Laboratory Standard is clear on the requirement that all laboratory personnel receive the necessary information and training so that they understand the hazards of the chemicals present in their work area. The primary responsibility for ensuring this rests with the Principal Investigator, though EH&S provides various courses and classes to meet these needs. Chemical Safety Office staff can also help by providing guidance on common techniques and the use of common chemicals. However, the lab-specific training must be provided by the Principal Investigator (personally or by a designated staff member or outside source). The Principal Investigator must ensure that the information and training is presented before laboratory workers are allowed to use or handle chemicals in their laboratory.

## 11.1 Information

Laboratory personnel must be informed of:

- The contents of the Laboratory Standard and its appendices. Below is a link to the OSHA Laboratory Standard. This is also found in **Appendix B** of the *Laboratory Safety Guide*: https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.1450
- The location and availability of the UW-Madison Campus Chemical Hygiene Plan, The Lab-Specific Chemical Hygiene Plan and the Laboratory Safety Guide;
- The permissible exposure limits for OSHA-regulated substances or recommended exposure limits for other hazardous chemicals where there is no applicable OSHA standard (see **Appendix C** of this document for more information);
- Signs and symptoms associated with exposures to hazardous chemicals used in the laboratory;

- The location and availability of known reference materials on the hazards, safe handling, storage, and disposal of hazardous chemicals found in the laboratory including, but not limited to, Safety Data Sheets received from the chemical supplier.

## 11.2 Training

The Chemical Safety Staff offers regularly scheduled training on general laboratory safety. This covers details of the OSHA Laboratory Standard as well as campus safety policies (including the Campus CHP), resources, and services. Contact the Chemical Safety Office or visit the EH&S website (www.ehs.wisc.edu) for additional information.

Laboratory staff must also receive training on the laboratory-specific operations. This must include:

- The specific physical and health hazards (e.g., corrosive, carcinogenic, flammable, water-reactive chemicals) associated with the hazardous chemicals staff may come in contact with in the laboratory where they work;
- The methods that are to be used to control these hazards, including engineering and administrative controls, and personal protective equipment;
- Any laboratory-specific emergency procedures and the location and proper use of safety equipment (e.g., fume hood, fire extinguisher, emergency eyewash, and shower);
- Methods and observations that may be used to detect the presence or release of a hazardous chemical (such as monitoring conducted by the employer, continuous monitoring devices, visual appearance or odor of hazardous chemicals when being released, etc.).

Typically this training is provided by the Principal Investigator or other experienced laboratory staff member. Training must be communicated in a manner readily understood to those being trained. This may require written as well as oral transmission of information. The frequency of refresher training and information can be determined by the Principal Investigator. Refer to the Laboratory CHP template for information on documentation requirements.

## 12.0 Emergency Response

Each Principal Investigator must ensure that laboratory staff is knowledgeable and trained on emergency procedures. Many of the procedures are covered in other campus plans, including a building's Occupant Emergency Plan (OEP). The OEP is an all-hazard plan designed around a building's unique layout and function. The primary purpose of the OEP is to provide guidance to building occupants in the event of an emergency, such as a tornado, active shooter, gas leak or bomb threat. Contact your building manager or department chair for location of this document.

Assess the hazards present in your workspace and tailor your emergency equipment and response plans accordingly. Emergency response plans should be developed covering lab-specific procedures, including:

- Procedures for handling small and large chemical spills;
- Procedures for responding to fires;
- Procedures for handling instrument failures;
- Procedures for handling ventilation failures;
- Procedures for responding to local alarms, such as oxygen or toxic gas sensors.

In case of an emergency, be prepared to follow the planned emergency procedures for your workplace and building. Before an emergency strikes, there are several things that can be done to improve preparedness.

- Review your building's emergency plans, taking note of proper exit and reentry procedures and emergency contacts. Make sure these procedures and contacts are visibly posted and that all employees are familiar with them.
- Check your Laboratory Emergency Information Card (located near the laboratory entrance) and make sure the information is up to date. Keep your SDS files up to date and easily accessible.
- Locate and become knowledgeable with important emergency equipment in the laboratory such as fire extinguishers, eyewash stations, and spill kits. Have several of the laboratory employees trained on proper use of first aid and fire extinguishers.
- Periodically check the emergency equipment to make sure it is properly maintained, appropriate for the hazard and ready for use. For example, eyewash stations need to be flushed weekly to make sure the water is clean and adequately dispensed. Also, if you have acids in the lab, a spill kit for flammable liquids will be insufficient.
- Have emergency contacts posted:

  UW Police: 911  
  UW Hospital ER: 262-2398  
  UW Hospital Poison Control: 262-3702

  Dialing 911 on a landline phone will go directly to UW Police dispatch. Calling 911 from a cell phone will connect you to the Dane County dispatch. When calling from a cell phone either ask to be put through to UW dispatch or make clear that you are calling from a campus facility.

## 13.0 Exposure Monitoring

The State of Wisconsin regulations require exposure monitoring where exposure may occur at or above a published exposure value of OSHA or ACGIH (American Conference of Governmental Industrial Hygienists). Examples of such values could include the action level, permissible exposure level, threshold limit value, short-term exposure limit or ceiling limit. If you believe that you are being exposed to levels above the permissible limits, contact EH&S. The Environmental and Occupational Health (EOH) unit will, if deemed appropriate, ensure the necessary exposure monitoring is performed. The affected university staff will be notified by EOH staff of the results within 15 days of receipt of the results (see Section 5.3).

## 14.0 Respiratory Protection

As stated in Section 4.1, it is the policy of the university to take all prudent steps to minimize exposures to hazardous chemicals. This is primarily achieved by prudent experimental design and engineering controls. Examples include eliminating the hazard by substituting for a less hazardous alternative or containing the hazard through ventilation or other controls. If no alternatives can be found, then respiratory protection may be required.

Respirators include filtering face pieces (N95), cartridge respirators, powered air purifying respirators (PAPR) or self-contained breathing apparatus to prevent or limit exposure to airborne hazards. It is essential to evaluate the type and amount of the exposure to assure proper use and protection. There are a number of regulatory requirements associated with the use of respirators, including the development of a Respiratory Protection Program (RPP), conducting a medical evaluation and respiratory fit testing, and receiving training on the proper use of respirators. University Health Services can provide all necessary services and assist in the development of the RPP. Contact the Environmental and Occupational Health Program at 608-890-1992 or go to http://www.uhs.wisc.edu/occ-health/respiratoryprotection/ for additional information.

## 15.0 Medical Consultations and Evaluations

The university offers access to medical evaluation and associated services under the following circumstances:

- Signs or symptoms of exposure to chemical used in the laboratory are experienced;
- Exposure to an agent repeatedly occurs above a permissible level;
- A spill or release occurs resulting in agent exposure;
- Respirator use is required when working with the agent.

In addition to the circumstances listed above, there may be other occasions when consultation with either your personal physician or a university-affiliated Occupational Health physician may be warranted. Examples of such conditions may include pregnancy, desire to conceive or existence of a health condition which may put you at greater risk. To arrange for or discuss medical consultations and evaluations, contact the Occupational Medicine Program at 265-5610.

In the event of a possible exposure, the affected individual (or other laboratory staff present) must be prepared to supply the following information:

- The identity of the hazardous chemical(s) to which the worker may have been exposed;

- A description of the conditions under which the exposure occurred including quantitative exposure data, if available;
- A description of the signs and symptoms of exposure that the worker is experiencing, if any.

## 16.0 Laboratory Visit Program

The Laboratory Visitation Program is an ongoing program that provides assistance and consultation to help create a safe work environment. As part of the visit, EH&S Chemical Safety Office staff will help insure all university and governmental regulations are being complied with in the laboratories. The EH&S Laboratory Visitation Team performs a review of all safety documentation and physical hazards which include fire safety, chemical safety, engineering controls, and safety training. Upon completion of the laboratory visit, a report is issued to each laboratory manager. This report outlines areas that need improvement as well as any necessary guidance documents. EH&S staff are available to assist in making improvements.

The Chemical Safety Office visits laboratories by departments on a rotating basis. However, the Chemical Safety Office staff is available to visit any laboratory upon request. To schedule a laboratory visitation contact the Chemical Safety Office of EH&S at 265-5700.

For additional information on the Laboratory Visit Program, visit the EH&S website: http://www.ehs.wisc.edu/inspectionsandoutreach.htm

## 17.0 Incident/Accident Notification Investigation

Principal Investigators and supervisors must report any incident involving personal injury, exposure or illnesses, unintended fire, property damage or incidents involving an environmental release of hazardous materials directly to EH&S (call 265-5000) or through with EH&S website: www.ehs.wisc.edu

A primary tool to identify and recognize the areas responsible for accidents is a properly conducted accident investigation. Accident investigations shall be conducted by the EH&S staff with the primary focus of understanding why the accident or near-miss occurred and what actions can be taken to prevent recurrence.

Procedures for investigating workplace accidents and hazardous materials exposures include:

- Visiting the accident scene as soon as possible;
- Interviewing injured workers and witnesses;
- Examining the workplace for factors associated with the accident/exposure;
- Determining the cause of the accident/exposure;
- Taking corrective action to prevent the accident/exposure from reoccurring;
- Recording the findings and corrective actions taken.

The investigation will be recorded in writing and will adequately identify the cause(s) of the accident or near-miss occurrence. Documentation of the investigation and all follow-ups will be prepared and maintained by a member of the EH&S staff performing the investigation.

## 18.0 Transportation and Shipping of Hazardous Materials

### 18.1 Shipping of Hazardous Materials

In order to protect the public at large, the US Department of Transportation (DOT) regulates the shipping and transportation of hazardous materials *in commerce* on roadways and airways. A hazardous material is defined as any substance or material that could adversely affect the safety of the public, handlers or carriers during transportation. All DOT hazardous materials are listed in the DOT's Hazardous Materials Table:

https://www.gpo.gov/fdsys/pkg/CFR-1998-title49-vol2/xml/CFR-1998-title49-vol2-part172.xml

The regulations for shipping hazardous materials apply to all individuals involved in the shipping process, including individuals who:

- Arrange for transport;
- Package materials;
- Mark and label packages;
- Prepare shipping papers;
- Handle, load, secure and segregate packages within a transport vehicle.

Non-compliance with these standards is subject to civil penalties up to $50,000 per violation and up to $100,000 if death, serious illness, severe injury to any person or substantial destruction of property. Criminal penalties may result in penalties up to 10 years imprisonment. The requirements can be found in 49 CFR Parts 171-178 and cover the documentation, packing, marking, and labeling of hazardous materials as well as the training of shippers, carriers, and handlers. International Air Transport Association (IATA) regulations also apply when shipping hazardous chemicals by common air carriers such as FedEx since these carriers require that IATA rules are met.

In addition to proper packaging and labeling, the regulations require that the individual receive training that must be refreshed at minimum of every three years or when there is a significant change in the regulations. EH&S offers shipping training to individuals on campus, with separate courses geared toward chemical, biological, and radiological materials.

*Important Note: With very few exceptions no hazards materials can be carried on or transported in checked luggage on any commercial airline flight. It is the responsibility of the PI to know which substances are hazardous, which are not, and to communicate this information to laboratory members.*

Contact EH&S at 265-5000 for information on training or other shipping concerns or go the EH&S website at www.ehs.wisc.edu

### 18.2 On-Campus Transportation of Hazardous Materials

Under the current regulations, UW-Madison is considered a government agency; therefore university employees transporting hazardous materials are not technically placing the materials "in commerce." As a result, university employees transporting hazardous materials between campus buildings on public roadways are exempt from the DOT Hazardous Material Regulations (i.e. the normal packaging, labeling, placarding, and documentation do not apply). However, individuals who move hazardous chemicals on campus are still subject to the following university requirements:

- The employees involved in moving the hazardous materials should be trained and familiar with its hazards and basic handling properties.
- Before moving the material, an emergency plan and spill kit must be available in case of an accident or environmental discharge.
- Secondary containment of hazardous materials must be used for all materials where there is a potential for a spill.
- Only university vehicles (i.e., not personal vehicles) can be used for the transportation of hazardous materials.
- Items of a dangerous nature are not allowed on any Madison Metro bus. These could include but are not limited to: flammable liquids; dangerous, toxic or poisonous substances; storage batteries; vessels containing caustic materials, chemicals, acids or alkalis.

See the EH&S Chemical Safety website for additional guidance on transportation of chemicals between campus buildings. Arrangements can be made with the Chemical Safety Office for transportation of large quantities of chemicals between buildings.

Hazardous waste is regulated by the US Environmental Protection Agency (EPA) in 40 CFR 260-265. The transportation of waste requires special marking, training, and documentation. Hazardous waste can only be transported by UW EH&S employees and approved contractors.

## 19.0 Records

Principal Investigators are required to maintain all worker records associated with their laboratories. These records include:

- Copies of Laboratory CHPs;
- Training records for laboratory personnel;
- Records of any internal audits or inspections;
- Results of any exposure monitoring.

Records of inspection results performed by EH&S staff will be maintained by EH&S. While training records for all lab-specific training must be maintained by the Principal

Investigator, documentation of training performed by other organizations on campus is often maintained by those organizations. Consult with the training organization to ensure that they maintain these records.

## 20.0 Acronyms

**ACGIH:** American Conference of Governmental Industrial Hygienists
**CARS:** Central Answering and Response Service
**CHO:** Chemical Hygiene Officer
**CHP:** Chemical Hygiene Plan
**COI:** Chemicals of Interest
**CSA:** Controlled Substance Act
**CSC:** Chemical Safety Committee
**DEA:** Drug Enforcement Agency
**DHS:** Department of Homeland Security
**DOT:** Department of Transportation
**EH&S:** Environment, Health & Safety
**EPCRA:** Emergency Planning and Community Right-to Know Act
**FP&M:** Facilities Planning & Management
**IATA:** International Air Transport Association
**IBC:** International Building Code
**IFC:** International Fire Code
**MAQ:** Maximum Allowable Quantity
**MFD:** Madison Fire Department
**NFPA:** National Fire Protection Association
**OSHA:** Occupational Safety and Health Administration
**OSHMM:** On-Site Hazardous Materials Management
**PEL:** Permissible Exposure Level
**PHS:** Particularly Hazardous Substance
**PI:** Principal Investigator
**PPE:** Personal Protective Equipment
**SDS:** Safety Data Sheet
**SOP:** Standard Operating Procedure
**STEL:** Short Term Exposure Limit
**STQ:** Screening Threshold Quantity
**TLV:** Threshold Limit Value
**TPQ:** Threshold Planning Quantity
**TWA:** Time weighted average
**UHS:** University Health Services

## Appendix A1: Policy for the Purchase and Initial Use of High-Hazard Gas Cylinders

**Scope:** This policy applies to all UW-Madison faculty, staff, students and part-time employees that use compressed gas cylinders containing high-hazard gases in university facilities, including research and teaching laboratories.

**Background:** The University of Wisconsin-Madison is dedicated to providing a safe and healthy working environment for all faculty, staff, students and visitors. Cylinders containing compressed or liquefied gases pose a significant safety hazard if proper care is not taken in the storage, set-up, and use of the gases.

**Policy:** The University of Wisconsin-Madison requires approval by the Environment, Health & Safety Department (EH&S) prior to both the initial purchase and initial use of the high-hazard gases falling into the categories listed below. Approval is not required for re-orders of gas cylinders as long as their use has not changed. This policy is designed to ensure that the users have performed a hazard assessment, enacted appropriate engineering controls, and have received the necessary training prior to using the gases. It is the responsibility of the individual who intends to use a high-hazard gas to contact the Chemical Safety Office (within EH&S) prior to ordering. The Chemical Safety Office can be contacted via phone at 265-5700 or via email at chemsafety@fpm.wisc.edu.

The gases in the following hazard classes are subject to this policy:

1. All gases that are designated by Global Harmonization System (GHS) classification as Category 1 or 2 for acute toxicity;
2. All corrosive gases as designated by GHS, including both gases that are corrosive to the skin and/or corrosive to metal;
3. All pyrophoric gases.

Table A1 below lists some of the most common hazardous gases, by class, which fit the above criteria. This policy applies to the properties of the contents of cylinders taken as a whole, not the individual components. For example, a pure gas may have acute toxicity and be subject to this policy while a gas mixture containing a high percentage of an inert gas along with the same toxic gas may not be subject to this policy. Contact the Chemical Safety Office for additional information on which gases or gas mixtures may meet the above criteria.

NOTES: Certain vendors require formal risk assessments prior to selling specific gases – some which are outside the above criteria. In these instances EH&S will work with the vendors and UW staff to ensure that the assessments are performed. Use of gas cylinders is also subject to various restrictions and regulations as outlined in the *UW-Madison Campus Chemical Hygiene Plan and Policy*.

**Additional Information**

Information on the classes of gases subject to this policy is given below.

Gases with Acute Toxicity

Gases designated as Category 1 for acute toxicity have a median lethal concentration ($LC_{50}$) in air of 100 parts per million (ppm) or less by volume based on a 4-hour animal exposure. Category 2 gases have a $LC_{50}$ greater than 100 ppm and equal to/or greater than 500 ppm. When experimental values are taken from tests using a 1-hour exposure, they can be converted to a 4-hour equivalent by dividing the 1-hour value by a factor of 2 for gases and vapors. Safety Data Sheets for gases meeting these criteria (in addition to the Health Hazard GHS pictogram) will have the following hazard statement: "***Fatal if Inhaled"***

Pyrophoric Gases

A pyrophoric substance is a chemical that will ignite spontaneously in air at a temperature of 130 degrees Fahrenheit (54.4 degrees C) or below. Pyrophoric gases (in addition to the Flame GHS pictogram) will have the following hazard statement: ***"Catches fire spontaneously if exposed to air"***

Corrosive Gases

Gases designated as a skin corrosive cause visible destruction of, or irreversible

alterations in, living tissue by chemical action at the point of contact, typically based on 4-hour (or less) animal exposure studies. Gases designated as corrosive to metal have a corrosion rate on either steel or aluminum surfaces exceeding 6.25 mm per year at a test temperature of 55°C (131°F) when tested on both materials. Corrosive gases (in addition to the Corrosion GHS pictogram) will have the following hazard statements: ***"Causes severe skin burns and eye damage"*** or ***"May be corrosive to metals"***

More in-depth information on the Global Harmonization System can be found on the Occupational Safety and Health Administration's website.

- A guide to "*A Guide to the Globally Harmonized System of Classification and Labeling of Chemicals*" can be found at: https: https://www.osha.gov/dsg/hazcom/ghsguideoct05.pdf
- The Appendices to 29 CRF 1910.1200 (*Hazard Communication*) provide detailed information on the classifications. See Appendix A for information on acute toxicity and corrosion classes and Appendix B on pyrophoric materials. https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10099

**Table A1. List of Pure Gases Subject to this Policy**

Below is a list of common gases that fall into the three defined hazard classes which are subject to this policy. The list should not be construed as a complete list. Note that some gases fall into more than one class.

| Corrosive Gases | | |
|---|---|---|
| Ammonia ($NH_3$) | Chlorine Trifluoride ($ClF_3$) | Methylamine ($CH_3NH_2$) |
| Boron Trifluoride ($BF_3$) | Dichlorosilane ($SiH_2Cl_2$) | Nitric Oxide (NO) |
| Boron Trichloride ($BCl_3$) | Fluorine ($F_2$) | Sulfur Dioxide ($SO_2$) |
| Chlorine ($Cl_2$) | Hydrogen Bromide (HBr) | Sulfur Tetrafluoride ($SF_4$) |
| Chlorine Dioxide ($ClO_2$) | Hydrogen Chloride (HCl) | Trimethylamine ($N(CH_3)_3$) |
| | Hydrogen Fluoride (HF) | |

| Toxic gases | | |
|---|---|---|
| Arsine ($AsH_3$) | Formaldehyde ($CH_2O$) | Nickel Carbonyl [Ni $(CO)_4$] |
| Boron Trifluoride ($BF_3$) | Fluorine ($F_2$) | Nitrogen Dioxide ($NO_2$) |
| Chlorine ($Cl_2$) | Germane ($GeH_4$) | Phosgene ($COCl_2$) |
| Chlorine Dioxide ($ClO_2$) | Hydrogen Cyanide (HCN) | Phosphine ($PH_3$) |
| Chlorine Trifluoride ($ClF_3$) | Hydrogen Selenide ($H_2Se$) | Stibine ($SbH_3$) |
| Diborane ($B_2H_6$) | Hydrogen Sulfide ($H_2S$) | Sulfur Tetrafluoride ($SF_4$) |
| Dichlorosilane ($SiH_2Cl_2$) | | |

| Pyrophoric Gases | | |
|---|---|---|
| Arsine ($AsH_3$) | Phosphine ($PH_3$) | Stibine ($SbH_3$) |
| Diborane ($B_2H_6$) | Silane ($SiH_4$) | |

**Appendix A2: Policy for the Use and Storage of Inert Cryogenic Liquids**

**Scope:** This policy applies to all UW-Madison faculty, staff, students and part time employees who use inert cryogenic liquids (including argon, nitrogen, and helium) in university facilities, including research and teaching laboratories. The Environment, Health & Safety Department (EH&S) has established this policy to provide a safe and healthy working environment for all faculty, staff and students. This policy is intended to ensure that facilities where inert cryogenic liquids are used and stored have the proper engineering controls and postings and that university staff are provided with the knowledge and training necessary to work safely when using inert cryogenic liquids.

**Background:** Cryogenic liquids are liquefied gases that are kept in their liquid state at very low temperatures. Cryogenic liquids have boiling points below -150°C (- 238°F). Inert cryogenic liquids do not undergo chemical reactions under normal conditions and are considered to be non-toxic. The gases they give off are colorless, odorless and tasteless which can make a leak or exposure difficult to detect. Their low temperatures can cause cryogenic burns on contact with skin and embrittle materials leading to structural damage. More significantly, the high expansion ratio of these liquids increases the potential to create dangerous oxygen deficient atmospheres leading to the possibility of asphyxiation of individuals working in or entering facilities. *See Appendices A and B for information on the asphyxiation hazards of inert cryogenics.* Without a proper hazard analysis followed by implementation of the necessary controls, university students and staff may be at risk for an adverse event.
*Note: While certain materials such as cryogenic liquid carbon dioxide do not technically fit in the definition of inert cryogenic liquids, many of the required elements outlined in the policy will be enforced as determined by EH&S.*

**Policy:** UW-Madison EH&S has defined four risk levels of hazard for facilities that use or store inert cryogenic liquids. These levels are outlined in Table 1. Each defined level imposes requirements on engineering controls, administrative controls, postings and training. All facilities where inert cryogenic liquids are used shall be evaluated and assigned a risk level by EH&S. Once a level is assigned by EH&S staff all required actions shall be taken to minimize the risk.

In order to enact this policy the following **responsibilities** are assigned:

**EH&S:** The Environment Health & Safety Department has the responsibility to:

- Establish reasonable risk-based levels for inert cryogenic liquid usage;
- Assess facilities housing inert cryogenic liquids to define the hazard level and recommend necessary controls;
- Provide training on general hazards associated with use of inert cryogenic liquids;
- Provide technical assistance to Principal Investigators and Facility Managers when necessary;

- Periodically review operations of all identified Level 2, 3, and 4 spaces to ensure that all required elements of the safety plan are enacted.

**Principal Investigators (PIs) or Facility Managers:** Principal Investigators, facility managers, or other personnel in charge of laboratories or other facilities have the responsibility to:

- Contact EH&S prior to initial use of inert cryogenic gases;
- Implement and maintain the controls and practices determined by policy and the hazard level set forth by EH&S;
- Ensure appropriate personnel have general and facility-specific training of hazards and appropriate procedures for working with cryogens;
- Maintain documentation of required activities (such as training, monitoring, calibrating detectors, etc.);
- Ensure that all oxygen monitors and other engineering controls are operating properly and that they are calibrated as required.

*Note: Some of these duties can be delegated to the Lab Manager/Safety Officer or other facility personnel.*

**Staff and Students:** Individuals working in facilities that use cryogenic liquids have the responsibility to:

- Understand the hazards associated with the use of cryogens;
- Follow the policies and lab rules set forth by the PI or facility manager;
- Only operate systems for which they are trained and authorized;
- Notify supervisor and/or PI of any apparent safety hazard.

**UW-Madison Chemical Safety Committee:** The UW-Madison Chemical Safety Committee reviews and approves policies related to the safety of university staff and students.

## Information on Policy Requirements and Implementation

This section provides details on additional requirements and information on policy implementation. Table 1 provides a summary of the levels referred to in this section.

### Hazard Evaluation Process

In order to evaluate the hazard of a particular room containing inert cryogenic liquids several parameters will be considered, including:

- The amount of cryogen present and how it is used;
- The size of the laboratory (See Table 2);
- Room ventilation;
- Failure modes (including worst-case scenarios) necessary to bring about a hazardous situation.

Using these criteria, the likelihood of a failure leading to an Oxygen Deficiency Hazard (ODH) will be assessed and a hazard level assigned. If the laboratory/facility operations change or the quantity of cryogenic liquid in the space is in either increased or decreased the space shall be reassessed.

**Engineering Controls**

Ventilation

The space where inert cryogenic liquids are stored or used must be properly ventilated according to National and State standards while also taking into account any additional ventilation needs due to the amount of material in that space. Under no circumstances shall inert cryogenic liquids be stored in an unventilated room.
For Level 4 facilities emergency ventilation is typically required where oxygen depletion can occur rapidly. The ventilation system will immediately increase the air exchange within the facility.

Oxygen Monitors

Room oxygen monitors must be in place in Level 3 and 4 facilities. Normally, these monitors will be set to alarm when the concentration of oxygen drops below 19.5%. The number of monitors needed and their placement will depend on the room dimensions, size of the cylinders, the quantity of the cylinders, the types of cryogenic gas being used, whether the gas is being piped into a room, and height of the ceiling. Liquid nitrogen is heavier than air, so it is recommended that the monitors are mounted closer to the ground as opposed to higher up in the air.

The oxygen monitors must give both audible and visual alarm when oxygen levels drop below the alarm point. The alarm must be noticeable before entering the room. In some instances the hazard evaluation will indicate the need for personal monitors to be carried by each individual entering the facility. Training and postings must include the necessary response to an alarm.
Each department/purchaser is responsible for ensuring that the oxygen monitors are operating properly and are calibrated as required. The Office of Chemical Safety will keep a record of facilities containing oxygen monitors and will ensure that maintenance is being performed by the perspective labs.

*You can contact EH&S for recommendations or examples of appropriate oxygen monitors.*

**Administrative Controls**

Administrative controls and workplace-specific rules should be in place to address any hazards in the lab. Common administrative controls that may be necessary include, but aren't limited to:

- Maximum quantity limits for room space;

- Written safe working procedures;
- A 2-person rule requirement;
- Limited access to hazardous areas;
- Emergency response procedures.

The appropriate administrative controls will be determined during the hazard assessment.

**Personal Protective Equipment (PPE)**

Appropriate PPE must be worn when handling or dispensing cryogenic liquids. When handling inert cryogenic liquids it is typically necessary to wear safety goggles, closed-toed shoes, long sleeved shirts and long pants at all times. Face shields and thermal gloves should be worn whenever filling a dewar or transferring large amounts of cryogenic liquid. These items must be provided by the employer and available to anyone working with cryogens.

**Storage**

Cryogens should be stored in containers specifically designed to house them. The containers should be insulated and double walled. Store all cryogenic liquid containers upright in well-ventilated areas. Handle them carefully, and avoid dropping, rolling or tipping them on their sides. Cryogen tanks and containers should not be stored near elevators, walkways and unprotected platform edges or in locations where heavy moving objects may strike or fall on them.

**Transporting Cryogenic Liquids**

Cryogenic liquid containers should be moved on a hand truck, cart, or other appropriate transportation method. Containers need to be secured while being transported and kept upright at all times. If inert cryogenic liquids must be transported by elevator, routes and procedures should be evaluated to ensure that the cryogens can be moved safely. In the event of a power failure a passenger would be trapped in the confined space of an elevator with the container containing the cryogenic liquid. Evaporation of the liquids could lead to displacement of oxygen.

Evaluation of the routes should take into account the amount of material being transported, the vessel used, typical evaporation rates, and ventilation in all locations, including elevators. Mitigating procedures such as sending containers alone on elevators or keeping others informed as to when cryogenic liquids are being transported may be required based on a hazard assessment.

**Training**

Students and staff working with or around cryogenic liquids must be trained on the procedures for its use and be made aware of the hazards involved. Training must be documented with trainee signatures and training dates. General training can be received through UW Madison's Office of Chemical Safety. Facility specific training must also be provided by the PI/Facility Manager or designee. The training received shall provide information on the following topics:

- Properties and hazards of the cryogen being used;
- Personal Protective Equipment (PPE) requirements;
- Facility-specific procedures, including appropriate handling and filling methods;
- Proper use and function of engineering controls, including oxygen monitors, instrument interlocks, fume hoods, and other room ventilation;
- Review of all administrative controls;
- Incident/Exposure response and emergency contact;
- Transporting cryogenic liquids.

**Signage/Postings**

Any facility categorized as level 2 or higher shall have signage and/or warning information posted at the room's entrance.

<u>Level 2 Signage:</u>
All rooms assigned as risk level 2 must be posted with a sign indicating the presence of an inert cryogenic liquid. The posting will be chosen at the discretion of the Office of Chemical Safety. The signage will be either:

**Warning Sign** informing the public of the presence of a cryogenic liquid. This sign indicates the potential for low oxygen environments.
**Danger Sign** with information on who to contact in case of emergency or other concerns. This indicates the potential for an oxygen deficiency hazard of %15 or less.

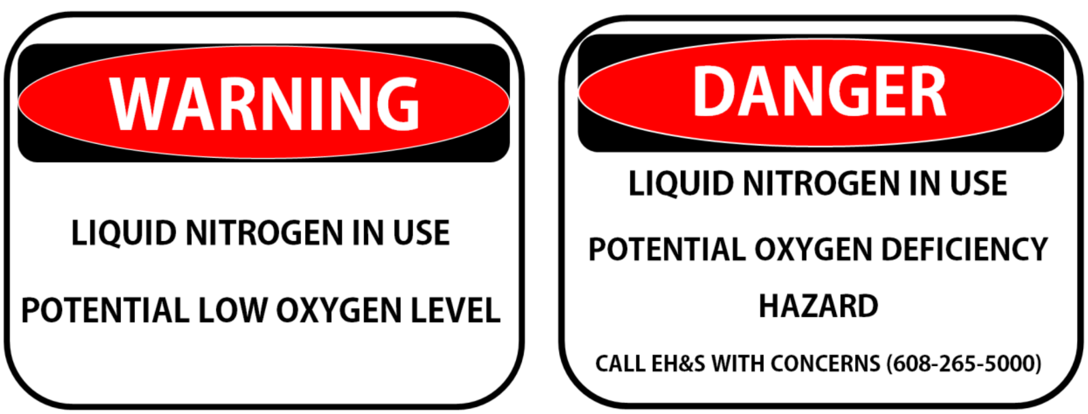


**Figure 1**: Example sign posting for a Level 2 facility

Level 3 and 4 Signage:

All rooms assigned as risk level 3 and 4 must be posted with a sign indicating the following:
-Presence of liquid nitrogen
-Do not enter if alarm is sounding
-Instructions for what to do in case of emergency

Level 4 facilities must also post entry requirements and may require additional signage or restrictions.


**Figure 2**: Example sign posting for Level 3 and 4 facilities

**Table 1. Risk Levels for Facilities using Inert Cryogenic Liquids**
***Oxygen Deficiency Hazard (ODH)**

| Level | Risk | General Requirements | Definition/ Typical Application |
|---|---|---|---|
| LEVEL 1 | Cold burn risk<br>Insignificant ODH | Inert Cryogenic Safety Training<br>(This includes PPE usage.) | Minimal use where a worst-case scenario (such as a Dewar spill) will not bring $O_2$ level below 18% |
| LEVEL 2 | Cold Burn Risk<br>Low ODH<br>Impaired coordination | Inert Cryogenic Training<br>Cryogen Signage and Postings: Warning/Danger (if levels can drop below %15)<br>Ventilation<br>Site specific training | Typical in locations where liquid nitrogen is stored or its use does not require extensive transfer. Worst-case scenario calculations may show that $O_2$ level may drop as low as 15%. Lower levels are possible if 2 independent modes of low probability are required to reach the level. |
| LEVEL 3 | Medium ODH<br>Impaired coordination, perception and judgment | Inert Cryogenic Training<br>Cryogen Signage and Postings<br>Ventilation<br>Oxygen Monitors | Typical in locations where large amounts of inert cryogenics are transferred or where a single failure mode can lead to oxygen levels below 15%. |
| LEVEL 4 | High ODH<br>Mental Failure, unconsciousness or death | Inert Cryogenic Training<br>Cryogen Signage and Postings<br>Ventilation<br>Oxygen Monitors<br>Plus some or all of the following:<br>• Personal Monitors<br>• 2-person rule<br>• Secured Facility<br>• Rescue Oxygen<br>• Emergency Ventilation | Highest hazard level. $O_2$ level may drop below 12% quickly in the event of a release or failure. **The Office of Chemical Safety must be notified and a hazard assessment must be performed.** |

**Table 2. Effects of Oxygen Deficiency**

| Oxygen Levels (%) | Symptoms of Exposure |
|---|---|
| 19.5 | Minimum oxygen level without adverse effect. |
| 15 to 19 | Decreased ability to work strenuously. Impaired coordination. Early symptoms. |
| 12 to 14 | Breathing rate increases, increase in heart rate. Impaired coordination, perception and judgment. |
| 10 to 12 | Breathing further increases in rate and depth, lips turn blue. Poor judgment. |
| 8 to 10 | Mental failure. Fainting. Nausea. Unconsciousness. Vomiting. |
| 6 to 8 | 8 minutes – fatal, 6 minutes – 50% fatal, 4 – 5 minutes – possible recovery. |
| 4 to 6 | Coma in 40 seconds, Convulsions, Breathing stops, Death. |

**Table 3. OXYGEN CONCENTRATION as a Function of Lab Size and LN2 Spill Size**

| LABORATORY SIZE | | 17.5% $O_2$ | 15% $O_2$ | 12% $O_2$ | 8% $O_2$ |
|---|---|---|---|---|---|
| | 20 $ft^2$ | 1L | 2L | 3L | 4L |
| | 40 $ft^2$ | 2L | 4L | 5L | 8L |
| | 60 $ft^2$ | 3L | 6L | 8L | 12L |
| | 80 $ft^2$ | 4L | 7L | 11L | 16L |
| | 100 $ft^2$ | 5L | 9L | 14L | 20L |
| | 150 $ft^2$ | 8L | 14L | 21L | 30L |
| | 200 $ft^2$ | 11L | 18L | 25L | 40L |
| | 250 $ft^2$ | 13L | 23L | 35L | 50L |
| | 300 $ft^2$ | 16L | 30L | 40L | 55L |
| | 350 $ft^2$ | 18L | 30L | 50L | 70L |
| | 400 $ft^2$ | 21L | 35L | 55L | 80L |

***AMOUNTS OF LIQUID NITROGEN ARE APPROXIMATE AND HAVE BEEN ROUNDED TO THE NEAREST WHOLE LITER  These percentages are calculated under the following assumptions: No ventilation, standard temperature and pressure, 8 ft ceiling height and an expansion ratio of 694.***

# Appendix B: Exposure Limits

Laboratories as workplaces pose unique hazards. There is the potential for exposure to a large number of chemicals; but exposures, if they do occur, tend to be of short duration. All prudent steps should be taken to minimize exposure, but the steps should be risk based. Occupational exposure limits have been set by various organizations. Some of the limits are enforceable by law while others are recommendations only, with no legal bases. These limits still perform a needed function in aiding an informed risk assessment process. Below is a brief description of the major occupational exposure limits.

**Permissible Exposure Limits (PELs):**

OSHA sets enforceable permissible exposure limits (PELs) to protect workers against the health effects of exposure to hazardous substances. PELs are regulatory limits on the amount or concentration of a substance in the air. They may also contain a skin designation that serves as a warning of potential cutaneous absorption that should be prevented in order to avoid exceeding the absorbed dose received by inhalation at the permissible exposure level (PEL). Most OSHA PELs are based on an 8-hour work shift of a 40-hour work week time weighted average (TWA) exposure that an employee may be exposed to for a working lifetime without adverse effects. Some of the PELs are listed as ceiling values – concentrations above which a worker should never be exposed, or short-term exposure limits (STELs) – average concentrations which should not be exceeded over a 15 minute time period. To locate PELs on specific chemicals go to: https://www.osha.gov/dsg/annotated-pels/tablez-1.html.

**Threshold Limit Value (TLV®):**

Threshold Limit Value (TLV) are occupational exposure limit set by the American Conference of Governmental Industrial Hygienists (ACGIH). The time-weighted average TLV (TWA-TLV) is an airborne concentration of a gas or particle to which most workers can be exposed on a daily basis for a working lifetime without adverse effect (assuming an average exposure on the basis of a 8h/day, 40h/week work schedule). In addition ACGIH defines:

- Short-term exposure limits (TLV-STEL) which are concentrations above which a worker should not be exposed (averaged over 15 minutes). Exposures cannot be repeated more than 4 times per day;
- Ceiling limits (TLV-C) which are concentrations above which a worker should never be exposed.

TLVs are regulatory limits in the State of Wisconsin if OSHA does not designate a PEL for that specific gas or particulate. In many laboratories the TLV-STEL or TLV-C of a chemical are more appropriate values unless the individual routinely works with the chemical. Unfortunately values for TLVs are not available on the ACGIH website. Contact EH&S for assistance with TLVs.

**Recommended Exposure Limits (RELs)**

Recommended Exposure Limits (RELs) were developed the National Institute for Occupational Safety and Health (NIOSH). NIOSH is the principal federal agency engaged in research, education, and training related to occupational safety and health. The REL is a level that NIOSH believes would be protective of worker safety and health over a working lifetime if used in combination with engineering and work practice controls, exposure and medical monitoring, posting and labeling of hazards, worker training and personal protective equipment. RELs are not legally enforceable.

NIOSH is well known for its *NIOSH Pocket Guide to Chemical Hazards.* In addition to containing RELs, it also has information on incompatibilities and reactivities, exposure routes, symptoms of exposure, target organs, potential cancer site, PPE, and first aid. A searchable version of the guide can be found at http://www.cdc.gov/niosh/npg/ . The pocket guide can also be downloaded from this site.

**Immediately Dangerous to Life or Health (IDLH)**

NIOSH also provides concentrations for chemicals that it considers immediately dangerous to life or health (IDLH). NIOSH defines an IDLH condition as a situation "that poses a threat of exposure to airborne contaminants when that exposure is likely to cause death or immediate or delayed permanent adverse health effects or prevent escape from such an environment." IDLH values can be found in the *NIOSH Pocket Guide to Chemical Hazards* (see link above). The purpose for establishing this IDLH value was to determine a concentration from which a worker could escape without injury or without irreversible health effects. In determining IDLH values, the ability of a worker to escape without loss of life or irreversible health effects was considered along with severe eye or respiratory irritation and other effects (e.g., disorientation or incoordination) that could prevent escape. As a safety margin IDLH values were based on the effects that might occur as a consequence of a 30-minute exposure.

**Workplace Environmental Exposure Levels (WEELs)**

The American Industrial Hygiene Association (AIHA) develops worker exposure levels for health-based chemicals. Since most of the other worker protection limits are for commonly used industrial chemicals AIHA began developing Workplace Environmental Exposure Levels to meet a specific need. WEELs are air concentration guide values for agents in a healthy worker's breathing zone. WEELs are not enforceable but provide a good guideline when no other guidance exists. The latest WEELs can be found at:

https://www.aiha.org/get-involved/aiha-guideline-foundation/weels

## Appendix C:  Particularly Hazardous Substances

When working with hazardous materials, laboratory personnel need to understand the risks associated with the chemicals. Once the hazards are known then steps can be taken to minimize the risk associated with the hazard. Such steps include appropriate PPE and engineering controls, such as fume hoods. OSHA requires that special provisions be taken when working with Particularly Hazardous Substances (PHSs) since these substances potentially pose a higher health risk. PHSs are, according to OSHA, "select carcinogens", reproductive toxins, or substances that have a high degree of acute toxicity.

The OSHA requirements for working with PHSs are more a matter of degree than a clear-cut differentiation from other substances. Risk assessments must always be done. The Laboratory Standard simply requires that higher risk materials be identified and mandates that extra precautions be used, if appropriate.

Laboratory personnel must do their due diligence when planning an experiment or procedure to determine hazards. This appendix provides some information and links to resources that help you identify PHSs. It is impossible to provide a master list of all PHSs so the information below should not be considered as comprehensive. This is especially true at a research institution where exotic materials are used for which there is no toxicological information. Also, toxicity is often related to the chemical's form and how it is used. For example, compounds which are not considered highly dangerous may pose a much greater risk in the form of a nanoparticle. It is for this reason that prudent practices should always be taken to minimize exposures.

**Carcinogens**
"Select carcinogens" are any substances that meet one of the following criteria:

- It is regulated by OSHA as a carcinogen;
- It is listed under the category "known to be carcinogens," in the Annual Report on Carcinogens published by the National Toxicology Program (NTP; latest edition);
- It is listed under Group 1 ("carcinogenic to humans") by the International Agency for Research on Cancer Monographs (IARC; latest edition);
- It is listed in either Group 2A or 2B by IARC or under the category "reasonably anticipated to be carcinogens" by NTP.

The National Toxicology Program has a website that provides the most recent list of materials known or reasonably anticipated to be carcinogenic. The website also provides a profile for each of the chemicals summarizing the carcinogenicity, properties, uses, and exposure routes for the substance. The website can be accessed at:
https://ntp.niehs.nih.gov/pubhealth/roc/index-1.html
A list of all the materials for which the IARC has issued reports can be found at the following website:
http://monographs.iarc.fr/ENG/Classification/ClassificationsAlphaOrder.pdf
This site also indicates the category the material falls under, with Group 1, 2A, and 2B being the chemicals of greatest concern.

**Reproductive Toxins**
Reproductive toxins, according to OSHA, are chemicals that affect the reproductive capabilities including chromosomal damage (mutations) and effects on fetuses (teratogenesis). The Environmental Health and Safety Office at Iowa State University has compiled a list of carcinogens, reproductive toxins and teratogens on their website. This can be found at:
https://www.ehs.iastate.edu/publications/factsheets/CarcReproTerat.pdf

**Highly Toxic Compounds**
OSHA defines substances that have a high degree of acute toxicity as substances that are "fatal or cause damage to target organs as a result of a single exposure or exposures of short duration". Due to the recent changes in the OSHA Hazard Communication Standard and pending further guidance from OSHA, UW-Madison will continue to use the term "highly toxic" per the previous OSHA definition. According to OSHA, a chemical falling within any of the following categories is considered to be highly toxic:

- A chemical that has a median lethal dose $LD_{50}$ of 50 milligrams or less 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 $LD_{50}$ of 200 milligrams or less 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 rabbits weighing between two and three kilograms each;
- A chemical that has a median lethal concentration $LC_{50}$ in air of 200 parts per million by volume or less of gas or vapor, or 2 milligrams per liter or less 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.

A complete list of all highly toxic compounds is impossible to compile. The compounds listed below were obtained from Penn State University. This list is provided as an aid. Laboratory personnel must still do their due diligence when performing a risk assessment. Consult other sources whenever possible. The SDS should also be consulted as it often has NFPA or HMIS health ratings for the compounds.

**Table C1. List of Highly Toxic Compounds**

| COMPOUND | CAS # |
|---|---|
| ACETONE CYANOHYDRIN (DOT) | 75-86-5 |
| ACETONYLBENZYL)-4-HYDROXYCOUMARIN, 3-(ALPHA- | 81-81-2 |
| ACROLEIN, INHIBITED (DOT) | 107-02-8 |
| ACTIDIONE | 66-81-9 |
| ACTINOMYCIN D | 50-76-0 |
| AFLATOXINS | 1402-68-2 |
| ALDRIN (DOT) | 309-00-2 |

| | |
|---|---|
| ALLYL BROMIDE (DOT) | 106-95-6 |
| ALLYL ISOTHIOCYANATE | 57-06-7 |
| ALLYLIDENE DIACETATE | 869-29-4 |
| ALUMINUM PHOSPHIDE (DOT) | 20859-73-8 |
| AMINO PYRIDINE, 2- | 504-29-0 |
| AMINOPTERIN | 54-62-6 |
| AMINOPYRIDINE, 4- | 504-24-5 |
| ANTU (NAPHTHYLTHIOUREA, ALPHA-) | 86-88-4 |
| ARSENIC ACID, SODIUM SALT (SODIUM ARSENATE) | 7631-89-2 |
| ARSENIC ACID, SOLUTION | 7778-39-4 |
| ARSENIC IODIDE | 7784-45-4 |
| ARSENIC PENTASULFIDE | 1303-34-0 |
| ARSENIC PENTOXIDE (DOT) | 1303-28-2 |
| ARSENIC TRICHLORIDE | 7784-34-1 |
| ARSENIC TRIOXIDE | 1327-53-3 |
| ARSENIC TRISULFIDE | 1303-33-9 |
| ARSENIOUS ACID (ARSENIC TRIOXIDE, SOLID) | 1327-53-3 |
| ARSENIOUS OXIDE (ARSENIC TRIOXIDE, SOLID) | 1327-53-3 |
| ARSINE | 7784-42-1 |
| AZINPHOS-METHYL | 86-50-0 |
| AZIRIDINE | 151-56-4 |
| BAY 25141 | 115-90-2 |
| BENZEDRINE | 300-62-9 |
| BENZENETHIOL (PHENYL MERCAPTAN) (DOT) | 108-98-5 |
| BIDRIN | 141-66-2 |
| BORON TRIFLUORIDE | 7637-07-2 |
| BUSULFAN | 55-98-1 |
| BUTANEDIOL DIMETHYLSULFONATE, 1,4- | 55-98-1 |
| BUTYL-4,6-DINITROPHENOL, 2-SEC- | 88-85-7 |
| CALCIUM ARSENATE, SOLID | 7778-44-1 |
| CALCIUM CYANIDE | 592-01-8 |
| CARBON OXYFLUORIDE | 353-50-4 |
| CARBONYL CHLORIDE | 75-44-5 |
| CARBONYL FLUORIDE | 353-50-4 |
| CARBONYL SULFIDE | 463-58-1 |
| CHLORINATED DIPHENYL OXIDE | 31242-93-0 |
| CHLORINE (DOT) | 7782-50-5 |
| CHLORINE PENTAFLUORIDE | 13637-63-3 |
| CHLORINE TRIFLUORIDE | 7790-91-2 |
| CISPLATIN | 15663-27-1 |
| CYANOGEN | 460-19-5 |
| CYANOGEN CHLORIDE | 506-77-4 |
| CYCLOHEXIMIDE | 66-81-9 |
| CYCLOPHOSPHAMIDE | 50-18-0 |
| DASANIT | 115-90-2 |
| DAUNOMYCIN | 20830-81-3 |
| DDVP (DICHLORVOS) | 62-73-7 |
| DEMETON, MIXED ISOMERS | 8065-48-3 |
| DICHLORO-N-METHYLDIETHYLAMINE, 2,2'- | 51-75-2 |
| DICHLORVOS | 62-73-7 |
| DICROTOPHOS | 141-66-2 |
| DIELDRIN (DOT) | 60-57-1 |
| DIETHYL S-[2-(ETHYLTHIO)ETHYL]PHOSPHORODITHIOATE, O- | 298-04-4 |

| | |
|---|---|
| DIETHYLHYDRAZINE, 1,2- | 1615-80-1 |
| DIISOPROPLY FLUOROPHOSPHATE | 55-91-4 |
| DIMETHYL MERCURY | 593-74-8 |
| DINITRO-O-CRESOL, 4,6- | 534-52-1 |
| DINITROPHENOL, 2, 4- | 51-28-5 |
| DINOSEB | 88-85-7 |
| DIOXATHION | 78-34-2 |
| DISULFOTON | 298-04-4 |
| DNBP | 88-85-7 |
| ENDOSULFAN | 115-29-7 |
| ENDRIN | 72-20-8 |
| EPN | 2104-64-5 |
| ETHION | 563-12-2 |
| ETHYLENEIMINE (DOT) | 151-56-4 |
| FENAMIPHOS | 22224-92-6 |
| FENSULFOTHION | 115-90-2 |
| FLUOROACETIC ACID, SODIUM SALT | 62-74-8 |
| FONOFOS | 944-22-9 |
| GLYCOLONITRILE | 107-16-4 |
| GUTHION | 86-50-0 |
| HEPTACHLOR | 76-44-8 |
| HEPTACHLOR EPOXIDE | 1024-57-3 |
| HYDROCYANIC ACID, LIQUIFIED | 74-90-8 |
| HYDROGEN CHLORIDE GAS | 7647-01-0 |
| HYDROGEN CYANIDE | 74-90-8 |
| HYDROGEN FLUORIDE GAS | 7664-39-3 |
| HYDROXY-3(3-OXO-1-PHENYLBUTYL)-2H-1-BENZOPYRAN-2-ONE | 81-81-2 |
| IRON PENTACARBONYL | 13463-40-6 |
| LANNATE | 16752-77-5 |
| MELPHALAN | 148-82-3 |
| MERCURIC CHLORIDE | 7439-97-6 |
| METHYL CYCLOPENTADIENYL MANGANESE TRICARBONYL, 2- | 12108-13-3 |
| METHYL HYDRAZINE | 60-34-4 |
| METHYL IODIDE | 74-88-4 |
| METHYL MERCURY | 593-74-8 |
| METHYL PARATHION, LIQUID | 298-00-0 |
| METHYL VINYL KETONE, INHIBITED (DOT) | 78-94-4 |
| METHYL-BIS(2-CHLOROETHYL) AMINE (NITROGEN MUSTARD), N- | 51-75-2 |
| METHYL-N-NITROSO-METHANAMINE,N- | 62-75-9 |
| METHYLAZIRIDINE, 2- (PROPYLENEIMINE, INHIBITED) | 75-55-8 |
| METHYLHYDRAZINE (DOT) | 60-34-4 |
| METHYLPROPYL)-4,6-DINITRO-PHENOL,2-(1- | 88-85-7 |
| MEVINPHOS | 7786-34-7 |
| MITOMYCIN C | 50-07-7 |
| MONOCROTOPHOS | 6923-22-4 |
| MYLERAN | 55-98-1 |
| NAPHTHYLTHIOUREA, ALPHA- | 86-88-4 |
| NITROGEN MUSTARD | 51-75-2 |
| NITROSODIMETHYLAMINE, N- | 62-75-9 |
| PARAQUAT, RESPIRABLE FRACTION | 2074-50-2 |

| | |
|---|---|
| PERFLUOROISOBUTYLENE | 382-21-8 |
| PHENYL MERCAPTAN (DOT) | 108-98-5 |
| PHENYLPHOSPHINE | 638-21-1 |
| PHORATE | 298-02-2 |
| PHOSDRIN (MEVINPHOS) | 7786-34-7 |
| PHOSGENE | 75-44-5 |
| PHOSHONOTHIOIC ACID, O-ETHYL O-(P-NITROPHENYL)ESTER, | 2104-64-5 |
| PHOSPHINE | 7803-51-2 |
| PHOSPHORUS PENTAFLUORIDE | 7641-19-0 |
| POTASSIUM CYANIDE, SOLID (DOT) | 151-50-8 |
| PREMERGE | 88-85-7 |
| PROPANENITRILE | 107-12-0 |
| PROPIONITRILE | 107-12-0 |
| PROPYLENEIMINE, INHIBITED (DOT) | 75-55-8 |
| SODIUM AZIDE | 26628-22-8 |
| SODIUM CYANIDE, SOLID (DOT) | 143-33-9 |
| STRYCHNINE, SOLID (DOT) | 57-24-9 |
| SULFOTEP | 3689-24-5 |
| SYSTOX | 8065-48-3 |
| TETRACHLORODIBENZO-P-DIOXIN, 2,3,7,8- (TCDD) | 1746-01-6 |
| TETRAETHYL DITHIOPYROPHOSPHATE (TEDP) | 3689-24-5 |
| TETRAETHYL LEAD, LIQUID | 78-00-2 |
| TETRAETHYLPYROPHOSPHATE, LIQUID | 107-49-3 |
| THIODAN (ENDOSULFAN) | 115-29-7 |
| THIOPHENOL (PHENYL MERCAPTAN) (DOT) | 108-98-5 |
| TRIETHYLENETHIOPHORAMIDE, N,N',N"- | 52-24-4 |
| TRIMETHYLENETRINITRAMINE | 121-82-4 |
| URACIL MUSTARD | 66-75-1 |
| VANADIUM PENTOXIDE | 1314-62-1 |
| VAPATONE (TETRAETHYLPYROPHOSPHATE, LIQUID) | 107-49-3 |
| WARFARIN | 81-81-2 |

## Appendix D: Chemical Storage Limits

The university is subject to the International Fire Code (IFC), by virtue of it being adopted by the Madison Fire Department (MFD), as well as the International Building Code since the State of Wisconsin has adopted the 2015 version. MFD also enforces sections of the National Fire Protection Association (NFPA) standards since these have been adopted by IFC reference.

The tables in this section attempt to portray the limits that are imposed by the codes mentioned above. The maximum allowable quantities (MAQs) listed below are per control area. As discussed in Section 6.1 of this document a laboratory is not necessarily a control area – it may consist of more than one laboratory. These limits are therefore guidelines since it is beyond the scope of this document to provide information on each campus building. Most laboratories are unlikely to exceed the MAQs. In instances where the MAQs are approached, it is often possible to reduce the inventory on-hand by making minimal changes to procedures. Contact the Chemical Safety Office if you have any questions concerning the limits. Note: Only a few facilities have been specifically constructed to allow quantities in excess of the MAQs.

**Table D1.** This table provides a list of MAQs based on the class of material. The MAQs are defined below for the ground floor level (floor 1). Higher level floors and below grade floors decrease the MAQ as indicated in Table D2. The table includes storage limits and limits for usage in an open or closed system. IFC defines "open" and "closed" systems as the following:

> *OPEN SYSTEM.* The use of a solid or liquid hazardous material involving a vessel or system that is continuously open to the atmosphere during normal operations and where vapors are liberated, or the product is exposed to the atmosphere during normal operations. Examples of open systems for solids and liquids include dispensing from or into open beakers or containers, dip tank and plating tank operations.
>
> *CLOSED SYSTEM.* The use of a solid or liquid hazardous material involving a closed vessel or system that remains closed during normal operations where vapors emitted by the product are not liberated outside of the vessel or system and the product is not exposed to the atmosphere during normal operations; and all uses of compressed gases. Examples of closed systems for solids and liquids include product conveyed through a piping system into a closed vessel, system or piece of equipment.

Additional definitions are supplied at the end of this Appendix. When viewing Table D1 note the footnotes below the Tables. These indicate building or containment features that may increase the MAQs or, in some instances, are required. Also, the aggregate quantity in use and storage cannot exceed the quantity listed for storage. Table D1 assumes the laboratory is on the ground floor.

**Table D1. International Fire Code (IFC 2015) Maximum Allowable Quantities (MAQ) In Storage per Fire Control Areas**

| Hazardous Material | Class | Storage | Use (closed system) | Use (open system) |
|---|---|---|---|---|
| Flammable Liquid (gallons) | IA<br>IB or IC | 30[1,2]<br>120[1,2] | 30[1]<br>120[1] | 10[1]<br>30[1] |
| Combustible liquids (gallons) | II<br>IIIA | 120[1,2]<br>330[1,2] | 120[1]<br>330[1] | 30[1]<br>80[1] |
| Flammable gas, gaseous (cubic feet) | | 1000[1,2] | 1000[1,2] | NA |
| Flammable gas, liquefied (pounds) | | 150[1,2] | 150[1,2] | NA |
| Flammable solid (pounds) | | 125[1,2] | 125[1] | 25[1] |
| Cryogenics, flammable (pounds) | | 45[1] | 45[1] | 10[1] |
| Cryogenics, oxidizing (pounds) | | 45[1] | 45[1] | 10[1] |
| Organic peroxides (pounds) | UD<br>I<br>II<br>III | 1[2,4]<br>5[1,2]<br>50[1,2]<br>125[1,2] | 0.25[4]<br>1[1]<br>50[1]<br>125[1] | 0.25[4]<br>1[1]<br>10[1]<br>25[1] |
| Highly Toxic gases, gaseous (cubic feet) | | 20[1] | 20[1,3] | NA |
| Highly Toxic gases, liquefied (pounds) | | 4[1,3] | 4[1,3] | NA |
| Highly Toxic liquids or solids (pounds) | | 10[1,2] | 10[1] | 3[1] |
| Toxic gases, gaseous (cubic feet) | | 810[1,2] | 810[1,2] | NA |

| Hazardous Material | Class | Storage | Use (closed system) | Use (open system) |
|---|---|---|---|---|
| Toxic gases, liquefied (pounds) | | 150[1,2] | 150[1,2] | NA |
| Toxic liquids or solids (pounds) | | 500[1,2] | 500[1] | 125[1] |
| Oxidizing gas, gaseous (cubic feet) | | 1500[1,2] | 1500[1,2] | |
| Oxidizing gas, liquefied (pounds) | | 150[1,2] | 150[1,2] | |
| Pyrophoric solids or liquids (pounds) | | 4[2,4] | 1[4] | 0 |
| Pyrophoric gases (cubic feet) | | 50[2,4] | 10[2,4] | 0 |
| Unstable (reactive) solids or liquids (pounds) | 4<br>3<br>2 | 1[2,4]<br>5[1,2]<br>50[1,2] | 0.25[4]<br>1[1]<br>50[1] | 0.25[4]<br>1[1]<br>50[1] |
| Unstable (reactive) Gases (cubic feet) | 4<br>3<br>2 | 10[2,4]<br>50[1,2]<br>250[1,2] | 2[2,4]<br>10[1,2]<br>250[1,2] | |
| Water reactive (pounds) | 3<br>2 | 5[1,2]<br>50[1,2] | 5[1]<br>50[1] | 1[1]<br>10[1] |
| Corrosive, solids (pounds) | | 5000[1,2] | 5000[1] | 1000[1] |
| Corrosive, liquids (gallons) | | 500[1,2] | 500[1] | 100[1] |
| Corrosive, gases (cubic feet) | | 810[1] | 810[1] | |
| Corrosive, liquified gas (pounds) | | 150[1] | 150[1] | |

*NA = Not applicable; a cubic foot = 0.0283 $m^3$; 1 pound = 0.454 kg.; 1 gallon = 3.785 L.*

1. Maximum quantities shall be increased 100% (Table D1) for buildings equipped throughout with an automatic sprinkler. Where note 2 also applies the increase for both notes are to be applied accumulatively.
2. Maximum allowable quantities are to be increased up to 100% when stored in approved storage cabinets, gas cabinets, exhausted enclosures or safety cans as specified in IFC. Where note 1 also applies the increase for both notes are to be applied accumulatively.
3. Allowed only when stored in approved exhausted gas cabinets or exhausted enclosures as specified in the International Fire Code.
4. Permitted only in buildings equipped throughout with an automatic sprinkler system.

Additional Notes:
- The combined amounts of all classes (IA, IB, and IC) of flammable liquids cannot exceed the limits for the limits stated for (IB and IC).
- For chemicals that fit into multiple categories, the most restrictive limits apply

**Table D2.** The MAQs defined in Table D1 are defined for first floor occupancies. Other floors (both above and below grade) have lower MAQs based on a percentage of the 1st floor MAQ. Table D2 provide these percentages as well as the number of allowable control areas per floor.

**Table D2: % MAQs and No. of Control Areas by Floor**

| Floor Level | % of MAQ per Control Area | No. of Control Areas |
|---|---|---|
| 1 | 100 | 4 |
| 2 | 75 | 3 |
| 3 | 50 | 2 |
| 4 through 6 | 12.5 | 2 |
| 7 through 9 | 5 | 2 |
| 10 and above | 5 | 1 |
| Below Grade Level 1 | 75 | 1 |
| Below Grade Level 2 | 50 | 1 |

**Table D3.** NFPA 45 *Standard on Fire Protection for Laboratories Using Chemicals* sets limits on the quantities of flammable and combustible liquids that can be stored in any one container based on the construction of the container. Aggregate quantities must still be below the amounts indicated by Tables D1 and D2.

**Table D3. Maximum Allowable Size of Containers**

| ***Container Type*** | ***Flammable Liquids*** | | | ***Combustible Liquids*** | |
|---|---|---|---|---|---|
| | Class IA | Class IB | Class IC | Class II | Class III |
| Glass or approved plastic | 1 pt. | 1 qt. | 1 gal. | 1 gal. | 1 gal. |
| Metal (other than DOT drums) | 1 gal. | 5 gal. | 5 gal. | 5 gal. | 5 gal. |
| Safety cans | 2 gal. | 5 gal. | 5 gal. | 5 gal. | 5 gal. |
| Metal drums (DOT specifications) | 60 gal. | 60 gal. | 60 gal. | 60 gal. | 60 gal. |
| Approved portable tanks | 660 gal. | 660 gal. | 660 gal. | 660 gal. | 660gal. |

**Table D4.** The following chart lists the maximum volume of flammables and combustibles that can be stored in a single flammable storage cabinet. Again, quantities in a given control area cannot exceed MAQs listed above.

**Table D4. Maximum Storage Quantities for a Flammable Storage Cabinet**

| **MAXIMUM STORAGE QUANTITIES FOR CABINETS** | |
|---|---|
| ***Liquid Class*** | ***Maximum Storage Capacity*** |
| Flammable/Class I | 60 Gal. |
| Combustible/Class II | 60 Gal. |
| Combustible/Class III | 120 Gal. |
| Combination of classes | 120 Gal. |

*Not more than 60 gallons may be Class I and Class II liquids. No more than 120 gallons of Class III liquids may be stored in a storage cabinet, according to OSHA 29 CFR 1910.106(d)(3) and NFPA 30 Section 4-3.1.*

**Table D5.** The IFC limits the quantities of flammable liquids that can be stored in a control area. The MAQs are based on the classification of the flammable liquids. The following table provides NFPA classification information for some common solvents. The NFPA fire diamond information is often found on containers or in SDSs. Liquids with a flammability rating of 3 are considered Class IB and IC liquids while those with a flammability rating of 4 are Class IA. Note that Class IA, IB, and IC are flammable liquids. Class II liquids are combustible.

## Table D5. Flammable Liquid Storage, Properties and Classification

| Chemical | Flash Point (°F/ °C) | Boiling Point (°F/ °C) | IFC Classification |
|---|---|---|---|
| Acetic acid | 103/39 | 245/118 | II |
| Acetone | -4/-20 | 133/56 | 1B |
| Acetaldehyde | -38/-39 | 70/21 | IA |
| Acetonitrile | 42/6 | 179/82 | IB |
| Acrylonitrile | 32/0 | 171/77 | IB |
| Benzene | 12/-11 | 176/80 | IB |
| t-Butyl Alcohol | 52/11 | 181/83 | IB |
| Cyclohexene | 20/-7 | 181/83 | IB |
| Dioxane | 54/12 | 214/101 | IB |
| Ethyl Acetate | 24/-4 | 171/77 | IB |
| Ethyl Alcohol | 55/13 | 173/78 | IB |
| Ethyl Ether | -49/-45 | 95/35 | IA |
| Gasoline | -45/-43 | 100-400/38-204 | IB |
| Hexane | -7/-22 | 156/69 | IB |
| Isopropanol | 53/12 | 183/83 | IB |
| Methanol | 52/11 | 174/64 | IB |
| Methylene Chloride | none | 104/40 | - |
| Methyl Ethyl Ketone | 16/-9 | 176/80 | IB |
| Pentane | -40/ | 97/36 | IA |
| Petroleum Ether | 0/-18 | 95-140/35-60 | IA-IB |
| Propyl Alcohol | 74/23 | 207/97 | IC |
| n-Propyl Ether | 70/21 | 194/90 | IB |
| Pyridine | 68/20 | 239/115 | IB |
| Tetrahydrofuran | 6/-14 | 151/66 | IB |
| Toluene | 40/4 | 230/111 | IB |
| Triethylamine | 16/-7 | 193/89 | IB |
| m-Xylene | 77/25 | 282/138 | IC |

**Table D6.** The following table provides information on the hazards associated with common gases. This will aid risk assessments and also help determine MAQs. Since gases can fall into multiple categories (such as flammable and highly toxic) the most restrictive MAQ applies.

**Table D6. Hazards of Common Gases**

| Gas | Asphyxiant | Flammable | Oxidizer | Corrosive | Toxic | Highly Toxic | Pyrophoric | $LC_{50}$/PEL (ppm) |
|---|---|---|---|---|---|---|---|---|
| Ammonia ($NH_3$) | | | | X | X | | | 4000/50 |
| Arsine ($AsH_3$) | | X | | | | X | | 20/0.05 |
| Boron Tribromide ($BBr_3$) | | | | X | X | | | 380/1 |
| Boron Trichloride ($BCl_3$) | | | | X | X | | | 2541/5 |
| Bromine ($Br_2$) | | | X | X | | X | | 113/0.1 |
| Chlorine ($Cl_2$) | | | X | X | X | | | 293/1 |
| Chlorine Dioxide ($ClO_2$) | | | X | | X | | | 250/0.1 |
| Chlorine Trifluoride ($ClF_3$) | | | X | | X | | | 299/0.1 |
| Diborane ($B_2H_6$) | | X | | | | X | X | 80/0.1 |
| Dichlorosilane ($SiH_2Cl_2$) | | X | | X | X | | | 314/5 |
| Ethylene Oxide ($C_2H_4O$) | | X | | | X | | | 4350/1 |
| Fluorine ($F_2$) | | | X | X | | X | | 185/0.1 |
| Germane ($GeH_4$) | | X | | | X | | | 622/0.2 |

| Gas | Asphyxiant | Flammable | Oxidizer | Corrosive | Toxic | Highly Toxic | Pyrophoric | $LC_{50}$/PEL (ppm) |
|---|---|---|---|---|---|---|---|---|
| Hydrogen ($H_2$) | **X** | **X** | | | | | | |
| Hydrogen Bromide (HBr) | | | | **X** | | | | 2860/3 |
| Hydrogen Chloride (HCl) | | | | **X** | | | | 2810/5 |
| Hydrogen Cyanide (HCN) | | **X** | | | | **X** | | 40/10 |
| Hydrogen Fluoride (HF) | | | | **X** | **X** | | | 1300/3 |
| Methyl Bromide ($CH_3Br$) | | **X** | | | **X** | | | 1007/20 |
| Nickel Carbonyl [Ni $(CO)_4$] | | **X** | | | | **X** | | 18/0.001 |
| Nitrogen Dioxide ($NO_2$) | | | **X** | | **X** | | | 115/5 |
| Oxygen ($O_2$) | | | **X** | | | | | |
| Phosgene ($COCl_2$) | | | | | | **X** | | 5/0.1 |
| Phosphine ($PH_3$) | | | | | | **X** | **X** | 20/0.3 |
| Silane ($SiH_4$) | | **X** | | | **X** | | **X** | 9600/5 |
| Sulfur Dioxide ($SO_2$) | | | | **X** | | | | 2520/5 |

**Note:** Argon, carbon dioxide, helium and nitrogen are asphyxiating gases.
**PEL:** Permissible exposure limit.
**$LC_{50}$:** For inhalation experiments, the concentration of the chemical in air that kills 50% of the test animals in a given time (usually four hours) is the $LC_{50}$ value.

**DEFINITIONS:**

**COMBUSTIBLE LIQUID.** A liquid having a closed cup flash point at or above 100°F (38°C). Combustible liquids shall be subdivided as follows:

> **Class II.** Liquids having a closed cup flash point at or above 100°F (38°C) and below 140°F (60°C).
> **Class IIIA.** Liquids having a closed cup flash point at or above 140°F (60°C) and below 200°F (93°C).
> **Class IIIB.** Liquids having a closed cup flash point at or above 200°F (93°C).
> The category of combustible liquids does not include compressed gases or cryogenic fluids.

**CONTROL AREA.** Spaces within a building that are enclosed and bounded by exterior walls, fire walls, fire barriers and roofs, or a combination thereof, where quantities of hazardous materials not exceeding the maximum allowable quantities per control area are stored, dispensed, used or handled.

**CORROSIVE.** A chemical that causes visible destruction of, or irreversible alterations in, living tissue by chemical action at the point of contact. A chemical shall be considered corrosive if, when tested on the intact skin of albino rabbits by the method described in DOT 49 CFR, Part 173.137, such a chemical destroys or changes irreversibly the structure of the tissue at the point of contact following an exposure period of 4 hours. This term does not refer to action on inanimate surfaces. Highly acidic and basic compounds are typical examples of corrosive materials.

**CRYOGENIC FLUID.** A liquid having a boiling point lower than -150°F (-101°C) at 14.7

**FLAMMABLE LIQUID.** A liquid having a closed cup flash point below 100°F (38°C). Flammable liquids are further categorized into a group known as Class I liquids. The Class I category is subdivided as follows:

> **Class IA.** Liquids having a flash point below 73°F (23°C) and a boiling point below 100°F (38°C).
> **Class IB.** Liquids having a flash point below 73°F (23°C) and a boiling point at or above 100°F (38°C).
> **Class IC.** Liquids having a flash point at or above 73°F (23°C) and below 100°F (38°C).
> This category of flammable liquids does not include compressed gases or cryogenic fluids.

**FLAMMABLE SOLID.** A solid, other than a blasting agent or explosive, that is capable of causing fire through friction, absorption or moisture, spontaneous chemical change, or retained heat from manufacturing or processing, or which has an ignition temperature below 212°F (100°C) or which burns so vigorously and persistently when ignited as to create a serious hazard. A chemical shall be considered a flammable solid as determined in accordance with the test method of CPSC 16 CFR; Part 1500.44, if it ignites and burns with a self-sustained flame at a rate greater than 0.1 inch (2.5 mm) per second along its major axis.

**FLASH POINT.** The minimum temperature in degrees Fahrenheit at which a liquid will give off sufficient vapors to form an ignitable mixture with air near the surface or in the container, but will not sustain combustion. The flash point of a liquid shall be determined by appropriate test procedure and apparatus as specified in ASTM D 56, ASTM D 93 or ASTM D 3278.

**HIGHLY TOXIC.** A material which produces a lethal dose or lethal concentration that falls within any of the following categories:

1. A chemical that has a median lethal dose ($LD_{50}$) of 50 milligrams or less per kilogram of body weight when administered orally to albino rats weighing between 200 and 300 grams each.
2. A chemical that has a median lethal dose ($LD_{50}$) of 200 milligrams or less 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 rabbits weighing between 2 and 3 kilograms each.
3. A chemical that has a median lethal concentration ($LC_{50}$) in air of 200 parts per million by volume or less of gas or vapor, or 2 milligrams per liter or less of mist, fume or dust, when administered by continuous inhalation for 1 hour (or less if death occurs within 1 hour) to albino rats weighing between 200 and 300 grams each.

Mixtures of these materials with ordinary materials, such as water, might not warrant classification as highly toxic. While this system is basically simple in application, any hazard evaluation that is required for the precise categorization of this type of material shall be performed by experienced, technically competent persons.

**ORGANIC PEROXIDE.** An organic compound that contains the bivalent -O-O- structure and which may be considered to be a structural derivative of hydrogen peroxide where one or both of the hydrogen atoms have been replaced by an organic radical. Organic peroxides can pose an explosion hazard (detonation or deflagration) or they can be shock sensitive. They can also decompose into various unstable compounds over an extended period of time.

**Class I.** Those formulations that are capable of deflagration but not detonation.

**Class II.** Those formulations that burn very rapidly and that pose a moderate reactivity hazard.

**Class III.** Those formulations that burn rapidly and that pose a moderate reactivity hazard.

**Class IV.** Those formulations that burn in the same manner as ordinary combustibles and that pose a minimal reactivity hazard.

**Class V.** Those formulations that burn with less intensity than ordinary combustibles or do not sustain combustion and that pose no reactivity hazard.

**Unclassified detonable.** Organic peroxides that are capable of detonation. These peroxides pose an extremely high explosion hazard through rapid explosive decomposition.

**OXIDIZER.** A substance capable of oxidizing a reducing agent. Oxidizers are chemicals such as oxygen, chlorine, perchlorate and permanganates that support combustion but do not burn independently. Oxidizers can react violently with flammable and combustible materials.

**Oxidizers are subdivided as follows:**

**Class 4.** An oxidizer that can undergo an explosive reaction due to contamination or exposure to thermal or physical shock. Additionally, the oxidizer will enhance the burning rate and can cause spontaneous ignition of combustibles.

**Class 3.** An oxidizer that will cause a severe increase in the burning rate of combustible materials with which it comes in contact or that will undergo vigorous self-sustained decomposition due to contamination or exposure to heat.

**Class 2.** An oxidizer that will cause a moderate increase in the burning rate or that causes spontaneous ignition of combustible materials with which it comes in contact.

**Class 1.** An oxidizer whose primary hazard is that it slightly increases the burning rate but which does not cause spontaneous ignition when it comes in contact with combustible materials.

**OXIDIZING GAS.** A gas that can support and accelerate combustion of other materials.

**PYROPHORIC.** A chemical with an auto-ignition temperature in air, at or below a temperature of 130°F (54.4°C).

**TOXIC.** A chemical falling within any of the following categories:

1. A chemical that has a median lethal dose ($LD_{50}$) 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.
2. A chemical that has a median lethal dose ($LD_{50}$) 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 rabbits weighing between 2 and 3 kilograms each.
3. A chemical that has a median lethal concentration ($LC_{50}$) 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 2 milligrams per liter but not more than 20 milligrams per liter of mist, fume or dust, when administered by continuous inhalation for 1 hour (or less if death occurs within 1 hour) to albino rats weighing between 200 and 300 grams each.

**UNSTABLE (REACTIVE) MATERIAL.** A material, other than an explosive, which in the pure state or as commercially produced, will vigorously polymerize, decompose, condense or become self-reactive and undergo other violent chemical changes, including explosion, when exposed to heat, friction or shock, or in the absence of an inhibitor, or in the presence of contaminants, or in contact with incompatible materials. Unstable (reactive) materials are subdivided as follows:

> **Class 4.** Materials that in themselves are readily capable of detonation or explosive decomposition or explosive reaction at normal temperatures and pressures. This class includes materials that are sensitive to mechanical or localized thermal shock at normal temperatures and pressures.
>
> **Class 3.** Materials that in themselves are capable of detonation or of explosive decomposition or explosive reaction but which require a strong initiating source or which must be heated under confinement before initiation. This class includes materials that are sensitive to thermal or mechanical shock at elevated temperatures and pressures.
>
> **Class 2.** Materials that in themselves are normally unstable and readily undergo violent chemical change but do not detonate. This class includes materials that can undergo chemical change with rapid release of energy at normal temperatures and pressures, and that can undergo violent chemical change at elevated temperatures and pressures.
>
> **Class 1.** Materials that in themselves are normally stable but which can become unstable at elevated temperatures and pressure.

**WATER-REACTIVE MATERIAL.** A material that explodes; violently reacts; produces flammable, toxic or other hazardous gases; or evolves enough heat to cause self-ignition or ignition of nearby combustibles upon exposure to water or moisture. Water-reactive materials are subdivided as follows:

> **Class 3.** Materials that react explosively with water without requiring heat or confinement.
>
> **Class 2.** Materials that may form potentially explosive mixtures with water.
>
> **Class 1.** Materials that may react with water with some release of energy, but not violently, include bromine, chlorine and fluorine.

## Appendix E: EPCRA and DHS Laboratory Inventory Requirements

The University of Wisconsin-Madison is subject to two key regulations which require it to have knowledge of chemical inventories. The Emergency Planning and Community Right-to Know Act (EPCRA) requires the university to report quantities above specified thresholds for listed chemicals to state and local emergency planners. The Department of Homeland Security (DHS) also has created a list of Chemicals of Interest (COI) based on threat criteria such as sabotage, theft, and release. All chemical facilities in the U.S. must report any COIs maintained above the screening threshold quantities (STQs). In order to remain compliant the university requires that laboratory inventories of the specific chemicals (listed in the tables below) be maintained. Since most laboratories work with low quantities of material the lists have been truncated to include only those chemicals which have a low reporting threshold. Chemical spills involving chemicals on the EPCRA list should be reported to UW-Madison Chemical Safety Office since specific reporting requirements may apply.

Laboratory staff should consult the complete *EPA List of Lists* (http://www2.epa.gov/epcra/consolidated-list-lists) and the complete DHS COI list (at http://www.dhs.gov/xlibrary/assets/chemsec_appendixa-chemicalofinterestlist.pdf) when working with unusually large amounts of a hazardous chemical to determine whether the chemical should be included on their inventory. Contact the Chemical Safety Office for any questions on inventory requirements. The TPQs and STQs have been included for information purposes only.

### Table E1. EPCRA Inventory Requirements

Below is listed a subset of the EPCRA extremely hazardous substances list which have low threshold planning quantities (TPQs).

| Chemical | CAS # | Density (lbs/gal)[1] | Threshold Planning Quantity (lbs) | Reportable Volume (gal) | Reportable Volume (L) |
|---|---|---|---|---|---|
| Nickel carbonyl | 13463393 | 11.01 | 1 | 0.1 | 0.3 |
| 2-Chloro-N-(2-chloroethyl)-N-methylethanamine/ Mechlorethamine / Nitrogen mustard | 51752 | 9.31 | 10 | 1.1 | 4.1 |
| Carbonic dichloride / Phosgene | 75445 | 11.43 | 10 | 0.9 | 3.3 |
| Ethylene fluorohydrin | 371620 | 9.20 | 10 | 1.1 | 4.1 |
| Fluoroacetyl chloride | 359068 | 11.27 | 10 | 0.9 | 3.4 |
| Hydrogen selenide | 7783075 | Gas | 10 | | |
| Lewisite | 541253 | 15.73 | 10 | 0.6 | 2.4 |
| Methyl vinyl ketone | 78944 | 7.19 | 10 | 1.4 | 5.3 |
| Phorate | 298022 | 9.63 | 10 | 1.0 | 3.9 |
| Propargyl bromide | 106967 | 13.15 | 10 | 0.8 | 2.9 |

| Chemical | CAS # | Density (lbs/gal)[1] | Threshold Planning Quantity (lbs) | Reportable Volume (gal) | Reportable Volume (L) |
|---|---|---|---|---|---|
| Sarin | 107448 | 9.07 | 10 | 1.1 | 4.2 |
| Tabun | 77816 | 8.94 | 10 | 1.1 | 4.2 |
| 2-Propenoyl chloride / Acrylyl chloride | 814686 | 9.28 | 100 | 10.8 | 40.8 |
| Arsine | 7784421 | Gas | 100 | | |
| Benzene, 1,3-diisocyanato-2-methyl- / Toluene-2,6-diisocyanate | 91087 | 10.16 | 100 | 9.8 | 37.2 |
| Benzoic trichloride / Benzotrichloride | 98077 | 11.46 | 100 | 8.7 | 33.0 |
| Bis(chloromethyl) ether / Chloromethyl ether / Dichloromethyl ether / Methane, oxybis[chloro- | 542881 | 11.02 | 100 | 9.1 | 34.3 |
| Chlorine | 7782505 | Gas | 100 | | |
| Chloromethyl methyl ether / Methane, chloromethoxy- | 107302 | 8.83 | 100 | 11.3 | 42.9 |
| Cyanuric fluoride | 675149 | 13.33 | 100 | 7.5 | 28.4 |
| Diborane / Diborane(6) | 19287457 | Gas | 100 | | |
| Dicrotophos | 141662 | 10.13 | 100 | 9.9 | 37.4 |
| Diisopropylfluorophosphate / Isofluorphate | 55914 | 8.79 | 100 | 11.4 | 43.1 |
| Diphosphoramide, octamethyl- / Schradan | 152169 | 9.45 | 100 | 10.6 | 40.1 |
| Formothion | 2540821 | 11.34 | 100 | 8.8 | 33.4 |
| Hexachlorocyclopentadiene | 77474 | 14.18 | 100 | 7.1 | 26.7 |
| Hydrocyanic acid / Hydrogen cyanide | 74908 | 5.72 / Gas | 100 | 17 | 66.2 |
| Hydrofluoric acid / Hydrofluoric acid (conc. 50% or greater) | 7664393 | 8.35 | 100 | 12.0 | 45.4 |
| Hydrogen fluoride / Hydrogen fluoride (anhydrous) | 7664393 | Gas | 100 | | |
| Iron carbonyl (Fe(CO)5), (TB-5-11)- / Iron, pentacarbonyl- | 13463406 | 12.41 | 100 | 8.1 | 30.5 |
| Lithium hydride | 7580678 | Solid | 100 | | |
| Manganese, tricarbonyl methylcyclopentadienyl | 12108133 | 11.58 | 100 | 8.6 | 32.7 |
| Methacryloyl chloride | 920467 | 9.06 | 100 | 11.0 | 41.8 |
| Methacryloyloxyethyl isocyanate | 30674807 | 9.15 | 100 | 10.9 | 41.4 |
| Methyl phosphonic dichloride | 676971 | 11.58 | 100 | 8.6 | 32.7 |
| Nicotine / Pyridine, 3-(1-methyl-2-pyrrolidinyl)-,(S)- | 54115 | 8.41 | 100 | 11.9 | 45.0 |
| Nitric oxide / Nitrogen oxide (NO) | 10102439 | Gas | 100 | | |
| Nitrogen dioxide | 10102440 | 12.06 / Gas | 100 | 8.3 | 31.4 |
| Ozone | 10028156 | Gas | 100 | | |

| Chemical | CAS # | Density (lbs/gal)[1] | Threshold Planning Quantity (lbs) | Reportable Volume (gal) | Reportable Volume (L) |
|---|---|---|---|---|---|
| Parathion / Phosphorothioic acid, O,O-diethyl-O-(4-nitrophenyl) ester | 56382 | 10.50 | 100 | 9.5 | 36.7 |
| Phosphamidon | 13171216 | 10.11 | 100 | 9.9 | 37.5 |
| Phosphonothioic acid, methyl-, S-(2-(bis(1-methylethyl)amino)ethyl) O-ethyl ester | 50782699 | 8.40 | 100 | 11.9 | 45.1 |
| Phosphorus / Phosphorus (yellow or white) | 7723140 | Solid | 100 | | |
| Plumbane, tetramethyl- / Tetramethyllead | 75741 | 16.62 | 100 | 6.0 | 22.8 |
| Potassium cyanide | 151508 | Solid | 100 | | |
| Sodium cyanide (Na(CN)) | 143339 | Solid | 100 | | |
| Sulfur fluoride (SF4), (T-4)- / Sulfur tetrafluoride | 7783600 | Gas | 100 | | |
| Sulfur trioxide | 7446119 | Solid | 100 | | |
| Tellurium hexafluoride | 7783804 | Gas | 100 | | |
| TEPP / Tetraethyl pyrophosphate | 107493 | 9.87 | 100 | 10.1 | 38.3 |
| Terbufos | 13071799 | 9.20 | 100 | 10.9 | 41.1 |
| Tetraethyl lead | 78002 | 13.77 | 100 | 7.3 | 27.5 |
| Tetraethyltin | 597648 | 9.99 | 100 | 10.0 | 37.9 |
| Titanium chloride (TiCl4) (T-4)- / Titanium tetrachloride | 7550450 | 14.38 | 100 | 7.0 | 26.3 |
| Trichloro(chloromethyl)silane | 1558254 | 12.30 | 100 | 8.1 | 30.8 |
| Tris(2-chloroethyl)amine | 555771 | 10.29 | 100 | 9.7 | 36.8 |
| The Items with two threshold planning quantities listed (e.g., 1/10,000) are those where the lower TPQ number applies if the substance is present as a solid in powder form with particle size less than 100 microns, in solution or in molten form. Inventories must be maintained only when they are in the low TPQ form. | | | | | |
| Chromic chloride | 10025737 | Solid | 1/10,000 | | |
| Emetine, dihydrochloride | 316427 | Solid | 1/10,000 | | |
| 4,6-Dinitro-o-cresol | 534521 | Solid | 10/10,000 | | |
| Azinphos-methyl / Guthion | 86500 | Solid | 10/10,000 | | |
| Benzenearsonic acid | 98055 | Solid | 10/10,000 | | |
| Bis(chloromethyl) ketone | 534076 | Solid | 10/10,000 | | |
| Carbofuran | 1563662 | Solid | 10/10,000 | | |
| Cobalt carbonyl | 10210681 | Solid | 10/10,000 | | |
| Colchicine | 64868 | Solid | 10/10,000 | | |
| Digoxin | 20830755 | Solid | 10/10,000 | | |
| Dimethyl-p-phenylenediamine | 99989 | Solid | 10/10,000 | | |
| Dinitrocresol | 534521 | Solid | 10/10,000 | | |
| Diphacinone | 82666 | Solid | 10/10,000 | | |
| Endosulfan | 115297 | Solid | 10/10,000 | | |
| Fenamiphos | 22224926 | Solid | 10/10,000 | | |

| Chemical | CAS # | Density (lbs/gal)[1] | Threshold Planning Quantity (lbs) | Reportable Volume (gal) | Reportable Volume (L) |
|---|---|---|---|---|---|
| Fluoroacetic acid | 144490 | Solid | 10/10,000 | | |
| Fluoroacetic acid, sodium salt | 62748 | Solid | 10/10,000 | | |
| Monocrotophos | 6923224 | Solid | 10/10,000 | | |
| Organorhodium Complex (PMN-82-147) | 0 | Solid | 10/10,000 | | |
| Paraquat dichloride | 1910425 | Solid | 10/10,000 | | |
| Paraquat methosulfate | 2074502 | Solid | 10/10,000 | | |
| Sodium fluoroacetate | 62748 | Solid | 10/10,000 | | |

[1]Density (lb/gal) = specific gravity * 8.33

## Table E2. DHS Chemical of Interest Inventory Requirements

| Chemicals of Interest | Synonym | CAS Number | Min. Conc. (%) | STQs (in pounds unless otherwise noted) |
|---|---|---|---|---|
| Arsenic trichloride | Arsenous trichloride | 7784-34-1 | 30 | 2.2 |
| Arsine | | 7784-42-1 | 0.67 | 15 |
| 1,4-Bis(2-chloroethylthio)-nbutane | | 142868-93-7 | NA | 100g |
| Bis(2-chloroethylthio)methane | | 63869-13-6 | NA | 100g |
| Bis(2-chloroethylthiomethyl)ether | | 63918-90-1 | NA | 100g |
| 1,5-Bis(2-chloroethylthio)-npentane | | 142868-94-8 | NA | 100g |
| 1,3-Bis(2-chloroethylthio)-npropane | | 63905-10-2 | NA | 100g |
| 2-Chloroethylchloromethylsulfide | | 2625-76-5 | NA | 100g |
| Chlorosarin | o-Isopropyl methylphosphonochloridate | 1445-76-7 | NA | 100g |
| Chlorosoman | o-Pinacolyl methylphosphonochloridate | 7040-57-5 | NA | 100g |
| DF | Methyl phosphonyl difluoride | 676-99-3 | NA | 100g |
| N,N-(2-diethylamino)ethanethiol | | 100-38-9 | 30 | 2.2 |
| o,o-Diethyl S-[2-(diethylamino)ethyl] phosphorothiolate | | 78-53-5 | 30 | 2.2 |
| Diethyl methylphosphonite | | 15715-41-0 | 30 | 2.2 |
| N,N-Diethyl phosphoramidic dichloride | | 1498-54-0 | 30 | 2.2 |
| N,N-(2-diisopropylamino)ethanethiol N,N-diisopropyl-(beta)-aminoethane thiol | | 5842-07-9 | 30 | 2.2 |

| Chemicals of Interest | Synonym | CAS Number | Min. Conc. (%) | STQs (in pounds unless otherwise noted) |
|---|---|---|---|---|
| N,N-Diisopropyl phosphoramidic dichloride | | 23306-80-1 | 30 | 2.2 |
| N,N-(2-dimethylamino)ethanethiol | | 108-02-1 | 30 | 2.2 |
| N,N-Dimethyl phosphoramidic dichloride Dimethylphosphoramidodichloridate | | 677-43-0 | 30 | 2.2 |
| Dinitrogen tetroxide | | 10544-72-6 | 3.8 | 15 |
| N,N-(2-dipropylamino)ethanethiol | | 5842-06-8 | 30 | 2.2 |
| N,N-Dipropyl phosphoramidic dichloride | | 40881-98-9 | 30 | 2.2 |
| Fluorine | | 7782-41-4 | 6.17 | 15 |
| Germanium tetrafluoride | | 7783-58-6 | 2.11 | 15 |
| HN1 (nitrogen mustard-1) | Bis(2-chloroethyl)ethylamine | 538-07-8 | NA | 100g |
| HN2 (nitrogen mustard-2) | Bis(2-chloroethyl)methylamine | 51-75-2 | NA | 100g |
| HN3 (nitrogen mustard-3) | Tris(2-chloroethyl)amine | 555-77-1 | NA | CUM 100g |
| Hydrogen cyanide | Hydrocyanic acid | 74-90-8 | 4.67 | 15 |
| Hydrogen selenide | | 7783-07-5 | 0.07 | 15 |
| Isopropylphosphonothioic dichloride | | 1498-60-8 | 30 | 2.2 |
| Isopropylphosphonyl difluoride | | 677-42-9 | NA | 100g |
| Lewisite 1 | 2-Chlorovinyldichloroarsine | 541-25-3 | NA | 100g |
| Lewisite 2 | Bis(2-chlorovinyl)chloroarsine | 40334-69-8 | NA | 100g |
| Lewisite 3 | Tris(2-chlorovinyl)arsine | 40334-70-1 | NA | 100g |
| Methylphosphonothioic dichloride | | 676-98-2 | 30 | 2.2 |
| Sulfur mustard (Mustard gas(H)) | Bis(2-chloroethyl)sulfide | 505-60-2 | NA | 100g |
| O-Mustard (T) | Bis(2-chloroethylthioethyl)ether | 63918-89-8 | NA | 100g |
| Nitric oxide | Nitrogen oxide (NO) | 10102-43-9 | 3.83 | 15 |
| Nitrogen mustard hydrochloride | Bis(2-chloroethyl)methylamine hydrochloride | 55-86-7 | 30 | 2.2 |
| Nitrogen trioxide | | 10544-73-7 | 3.83 | 15 |
| Nitrosyl chloride | | 2696-92-6 | 1.17 | 15 |
| Oxygen difluoride | | 7783-41-7 | 0.09 | 15 |
| Phosgene | Carbonic dichloride;carbonyl dichloride | 75-44-5 | 0.17 | 15 |
| Phosphine | | 7803-51-2 | 0.67 | 15 |
| Propylphosphonothioic dichloride | | 2524-01-8 | 30 | 2.2 |
| Propylphosphonyl difluoride | | 690-14-2 | | 100g |
| Selenium hexafluoride | | 7783-79-1 | 1.67 | 15 |

| Chemicals of Interest | Synonym | CAS Number | Min. Conc. (%) | STQs (in pounds unless otherwise noted) |
|---|---|---|---|---|
| Sesquimustard | 1,2-Bis(2-chloroethylthio)ethane | 3563-36-8 | NA | 100g |
| Soman | o-Pinacolyl methylphosphonofluoridate | 96-64-0 | NA | 100g |
| Stibine | | 7803-52-3 | 0.67 | 15 |
| Sulfur tetrafluoride | Sulfur fluoride (SF4), (T-4)- | 7783-60-0 | 1.33 | 15 |
| Tabun | o-Ethyl-N,Ndimethylphosphoramido-cyanidate | 77-81-6 | NA | 100g |
| Tellurium hexafluoride | | 7783-80-4 | 0.83 | 15 |
| Thiodiglycol | Bis(2-hydroxyethyl)sulfide | 111-48-8 | 30 | 2.2 |
| VX | o-Ethyl-S-2-diisopropylaminoethyl methyl phosphonothiolate | 50782-69-9 | NA | 100g |