Chemical Hygiene Plan & Compliance

University of Tennessee Safety Guide LS-020

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1.0 Introduction

1.1. Purpose

The University of Tennessee, Knoxville chemical hygiene plan (UTK CHP) is designed to attain and maintain compliance with federal, state, and local regulations required for the use, storage, and disposition of hazardous chemicals. The UTK CHP defines a campus-wide approach for protecting employees and the environment from the health and physical hazards associated with chemicals used in instructional laboratories, research laboratories, shops and maker spaces.

The responsibility for ensuring a safe workplace is shared between faculty, staff and students. Environmental Health & Safety (EHS) professionals serve as a resource to assist faculty, staff and students in meeting this responsibility for laboratories and laboratory equivalents, departments, institutes, and research centers.

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 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 Tennessee Occupational Safety and Health Administration (TOSHA) has adopted the Laboratory Standard as part of its regulatory framework, applicable 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 chemical hygiene plan;
- Designating personnel to manage chemical safety

Other agencies, including the U.S. Environmental Protection Agency (EPA), the U.S. Department of Transportation (DOT), the Tennessee Department of Environment and Conservation (TDEC), and the Knoxville Fire Department (KFD) through adoption of International Building Code (IBC) standards, 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, Scope & Applicability

The UTK CHP 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, non-production basis. The plan outlines roles and responsibilities for key personnel, defines expectations and practices, and provides an understanding of the applicability of various regulations to operations in a campus laboratory.

All campus laboratories must comply with the requirements outlined in this document. Departments or organizations within or associated with the university are encouraged to create a departmental chemical hygiene plan (D-CHP) by supplementing the UTK CHP with their own procedures, programs and expectations. The D-CHP must retain the stringency of the UTK CHP.

Additionally, to fulfill the objectives of the standard, each laboratory possessing hazardous chemicals is *required* to supplement the UTK CHP with a laboratory-specific chemical hygiene plan (LS-CHP). LS-CHPs must include the following elements:

- Standard operating procedures (SOPs);
- Personal protective equipment (PPE) requirements;
- Engineering and administrative controls;
- Provisions for handling Particularly Hazardous Substances (PHS);
- Provisions for designating specific operations that shall require prior approval before initiation;
- Training requirements.

A template for a LS-CHP can be found in **Appendix A** of this document and on the EHS website (https://ehs.utk.edu/index.php/laboratory-safety/). The template includes instructions for completing the document. This template provides an organizational framework for ensuring that laboratory leaders are documenting and maintaining safety culture with respect to the use of hazardous chemicals and are compliant with OSHA laboratory safety regulations.

1.4. Program Implementation

The OSHA Laboratory Standard requires the designation of personnel responsible for implementation of a CHP. Specifically, it calls for the assignment of a Chemical Hygiene Officer (CHO). This individual has the responsibility for development and implementation of the UTK CHP and for ensuring the implementation of the requirement for LS-CHPs.

The CHO works with the UTK Laboratory Safety Committee (LSC) on the development of a campus-wide chemical safety and compliance program, including the UTK CHP. The LSC approves this plan and aids in its implementation. The LSC may delegate this responsibility to a subordinate committee (e.g. high-hazard chemical review committee, HHCRC) at its discretion.

For research laboratories on campus, the university designates the principal investigator (PI) as the individual responsible for developing and implementing the LS-CHP for laboratories under his/her control. While the PI can delegate health and safety responsibilities to a trained and knowledgeable individual, ultimate responsibility for compliance still resides with the PI.

Departments that have teaching laboratories or maker spaces containing hazardous chemicals should assign CHP attainment, implementation, and maintenance to a designated laboratory supervisor, facility manager, or departmental safety officer. Similarly, institutes should designate an institute supervisor, manager, or safety officer to fulfill CHP responsibilities.

1.5. Program Availability

All elements of the UTK CHP, including LS-CHPs, must be readily available to employees or employee representatives. Germane documents may be kept in hard copy or electronically.

1.6. Program Annual Review and Evaluation

The UTK CHO, in collaboration with the LSC or appointed subordinate committee (e.g. HHCRC), shall review and evaluate the effectiveness of the UTK CHP at least annually and update it as necessary. Updates to the UTK CHP will be posted to the EHS website.

For a LS-CHP to be useful, it must reflect the work that is currently performed within the laboratory. The PI must formally review the LS-CHP annually (at a minimum) to ensure that its contents are appropriate and adequate for current operations. If changes are necessary before the review date, the LS-CHP must be amended and the changes approved by the respective PI. The UTK CHO (or supporting EHS staff) will review the LS-CHP annually and upon substantial changes to the laboratory chemical risks (e.g. new highly hazardous chemical or procedure).

2.0 Roles and Responsibilities

To maintain an effective chemical hygiene plan, it is important for all parties to understand the responsibilities inherent in their roles. Below are assigned roles and responsibilities:

2.1. Director, Environmental Health & Safety Department

The Director of EHS will provide the necessary staffing and resources for maintaining an effective chemical safety program, including the UTK CHP.

2.2. Chemical Hygiene Officer, Environmental Health & Safety Department

The CHO has the primary responsibility for the development and implementation of the UTK CHP. The CHO will:

- Review and update the UTK CHP;
- Facilitate the campus community's understanding of, and compliance with, required chemical health and safety regulations;
- Provide technical guidance for the development and implementation of D-CHPs (as applicable), and LS-CHPs;
- Coordinate campus chemical emergency response with the UTK Office of Emergency Management, KFD, UT Police Department, or other emergency responders;
- Stop work when hazards or conditions exist that pose an immediate danger to the life or health of the laboratory (or adjacent) occupants, or when escalated safety violations are repeated.

2.3. Staff, Environmental Health & Safety Department

In support of the CHO, UTK EHS staff will:

- Provide training and technical guidance to PIs, laboratory supervisors/managers, and departmental safety officers (DSOs) on the UTK CHP (and D-CHPs as applicable), as well as the development and implementation of LS-CHPs and associated SOPs;
- Provide guidance for the safe handling, storage, and disposal of chemicals used on campus;
- Develop and prepare safety training specific to laboratory operations;

- Prepare and assist with laboratory commissioning and decommissioning procedures, particularly for hazardous chemicals;
- Assist with laboratory hazard assessments;
- Inspect laboratories and identify hazards and issues of non-compliance;
- Stop work when hazards or conditions exist that pose an immediate danger to the life or health of the laboratory (or adjacent) occupants, or when escalated safety violations are repeated;
- Provide electronic information, templates, forms, etc. for the EHS website.

2.4. UTK Laboratory Safety Committee

The UTK LSC is comprised of university faculty and staff drawn from many organizations and departments. The LSC will:

- Maintain, review, and provide improvements to campus procedures and guidelines on issues related to the purchase, use, storage, and disposal of chemicals;
- Review compliance with campus policies, plans, and procedures and recommend methods to promote compliance;
- Review the UTK CHP, and other university plans related to hazardous chemical use;
- Evaluate the broad needs for an effective campus-wide chemical hygiene plan. Make recommendations to EHS and, if necessary, to the campus administration, on such areas as staffing needs, funding sources, and required resources;
- Along with the CHO, determine the need for and purview of a high-hazard chemical review committee;
- Review incidents, accidents, and injuries related to the use of hazardous chemicals as reported by the campus CHO 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 laboratory personnel and the environment;
- Collaborate with other committees, including but not limited to the Campus Safety Committee, the Institutional Biosafety Committee, the Animal Care and Use Committee, Laser Safety Committee and Radiation Safety Committee, to ensure that chemical safety concerns are properly addressed.

2.5. Principal Investigator

The PI has the primary responsibility for creating and sustaining a safe work environment and for ensuring compliance with all elements of the UTK CHP and LS-CHP within his/her laboratory space(s). While the PI can delegate health and safety responsibilities to a trained and knowledgeable individual, the PI must ultimately ensure that the duties are performed. The PI must:

- Perform laboratory hazard analyses through the EHS electronic laboratory management system (BioRAFT), develop and approve SOPs, and ensure that PPE, engineering controls, and administrative controls described within the SOPs provide adequate protection to staff and students;
- 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' SDSs, the UTK CHP and LS-CHP, and other safety-related information for laboratory staff and students;
- Ensure that laboratory participants understand and follow the chemical safety practices, procedures, and regulations related to their laboratory's operation;
- Assess individual roles of their staff, students and faculty colleagues and hazards associated with those roles and document through the EHS electronic laboratory management system (BioRAFT);

- Ensure that PPE and required safety equipment are available and in working order and that laboratory personnel are trained in their use;
- Determine training requirements for laboratory workers based on their duties and tasks and ensure appropriate training specific to laboratory operations;
- Ensure that staff and students are knowledgeable about emergency plans, including fires, equipment failure, chemical exposures, and chemical spills;
- Utilize EHS-provided tracking software to manage chemical inventories, lab equipment, corrective actions tracking, lab-specific documentation (SOPs, LS-CHP, licenses & permits) and training;
- Maintain up-to-date chemical inventories through the EHS electronic laboratory management system (BioRAFT; see Section 6.2);
- Complete and keep the laboratory door placard up-to-date;
- Conduct regular chemical hygiene inspections and housekeeping inspections, including inspection of emergency equipment;
- Stop work when hazards or conditions exist that pose an immediate danger to the life or health of the laboratory (or adjacent) occupants;
- Correct any unsafe conditions identified within the laboratory through either self-inspections or inspections by EHS 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;
- Initiate laboratory commissioning/decommissioning procedure when appropriate (see https://ehs.utk.edu/index.php/table-of-policies-plans-procedures-guides/laboratory-decommissioning-commissioning/);
- Report any lab-related injury or significant exposure to EHS as quickly as possible;
- Submit accident reports to the UT Office of Risk Management within 24 hours of the incident.

2.6. Laboratory Personnel

The individuals working under the supervision of the PI will:

- Follow campus and laboratory practices, policies, and SOPs and as outlined in the UTK CHP and LS-CHP;
- Attend all safety training as required by the PI;
- Understand the inherent risk of any laboratory procedure;
- 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, compatibility and physical and toxicological properties of hazardous materials (such as SDSs, Prudent Practices in the Laboratory, the UTK Laboratory Safety Manual, and related articles found during a thorough literature search) prior to use of hazardous chemicals;
- Have knowledge of emergency procedures prior to working with hazardous chemicals;
- Incorporate safety in the planning of all experiments and procedures;
- Use the PPE and hazard control devices provided for his/her job;
- In accordance with EHS guidance, 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;

- Proactively report laboratory equipment or building infrastructure (e.g., eyewashes, outlets, benchtops, etc.) that is in poor repair or not working properly to the PI, DSO, EHS, and/or UT Facilities Services (the LiveSafe app may be used for such reporting);
- Keep work areas clean and orderly;
- Dispose of hazardous waste according to university procedures;
- Avoid behavior which could lead to injury;
- Not have unauthorized visitors while working;
- Report any unsafe condition immediately to the PI or other safety personnel;
- Stop work when hazards or conditions exist that pose an immediate danger to the life or health of the laboratory (or adjacent) occupants;
- Report incidents involving chemical spills, exposures, work-related injuries, and illnesses or unsafe conditions to PI;
- Consult with the PI or with EHS staff on any safety concerns or questions.

2.7. Department Heads & Institute Directors

Department heads and institute directors will:

- Promote a culture of safety within his/her area of responsibility;
- Provide support and enforcement for the policies and procedures contained in the UTK CHP, the Laboratory Safety Manual, university safety policies, and any other applicable safety and health rules and regulations;
- Per departmental discretion, supplement the UTK CHP with departmental procedures and requirements (i.e. create a D-CHP);
- Communicate safety requirements to departmental faculty, staff and students;
- Provide the resources needed to train employees in all aspects of their jobs relative to safety and health;
- Establish and implement any needed operational procedures for safety and health;
- Stop work when hazards or conditions exist that pose an immediate danger to the life or health of the laboratory (or adjacent) occupants;
- Investigate accidents and chemical exposures within the department;
- Monitor corrective action plans following laboratory assessments;
- Appoint a Departmental (or Institute) Safety Officer and empower him/her to assist in the implementation and maintenance of chemical hygiene (and other safety standards) within the department.

2.8. Departmental Safety Officers*

- Assist the department in maintaining compliance with the UTK CHP;
- Assist in developing, maintaining, and updating the D-CHP (as applicable) and LS-CHPs, particularly for departmental instructional laboratories;
- Assist the department in monitoring the procurement, use, storage, and disposal of chemicals;
- Assist in hazard assessments and the development of laboratory-specific SOPs as necessary;
- Stop work when hazards or conditions exist that pose an immediate danger to the life or health of the laboratory (or adjacent) occupants;
- Assist EHS in investigating accidents and chemical exposures within the department;
- Monitor corrective action plans following laboratory assessments;
- Act as a liaison between the department and EHS for laboratory safety issues;

- Attend LSC meetings and communicate updates and action items to departmental leadership.

*May also include laboratory supervisors/managers, institute safety officers or building safety coordinators as appointed and commissioned by the department or institute.

3.0 General Laboratory Rules and Expectations

Each PI has the responsibility to set rules and expectations for laboratories under his/her control as long as these are, at a minimum, compliant with regulations, the UTK CHP, and other applicable institutional requirements. Laboratory-specific expectations should be included in the LS-CHP.

4.0 Hazardous Chemical Identification and Controls

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. UTK takes a risk-based approach in determining means of mitigating risk, accounting for the characteristics of the chemical, the amounts used, the method in which a chemical is used, and the location.

4.2. Exposure Limits

It is the responsibility of the PI to communicate and collaborate with the CHO (and EHS support staff), DSOs, the LSC (or HHCRC) to ensure that laboratory staff members do not exceed exposure limits established for the chemicals that are used within the laboratory. OSHA has the regulatory authority to set specific exposure limits for chemicals. These permissible exposure limits (PELs) are listed in 29 CFR 1910.1000 TABLE Z-1. For chemicals that do not have a PEL listed in the OSHA standards, exposure limits established by the American Conference of Governmental Industrial Hygienists (ACGIH), e.g. threshold limit values (TLVs), should be referenced.

OSHA PELs and ACGIH TLVs were not created with a university laboratory setting in mind. These values reflect 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 (STELs), as established by OSHA and/or ACGIH, are often more appropriate. Many chemicals do not have any published exposure limits. For assistance with exposure monitoring, contact EHS at 865-974-5084 or ehs_labsafety@utk.edu. For more information on PELs, TLVs, and STELs, see **Appendix B**.

4.3. Hierarchy of Controls

To mitigate risks, the OSHA hierarchy of hazard controls (Figure 1) should be followed. Whenever possible, elimination 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 (e.g. fume hoods, glove boxes, or intrinsically safe equipment), administrative controls (e.g. policies against working alone), and personal protective equipment (e.g. gloves, eye protection, respirators, etc.). EHS provides tools to perform this risk assessment, including the [Laboratory Safety Manual](#) and other guidance documents. Additionally, EHS staff can provide consultation services if there are any questions on this process.

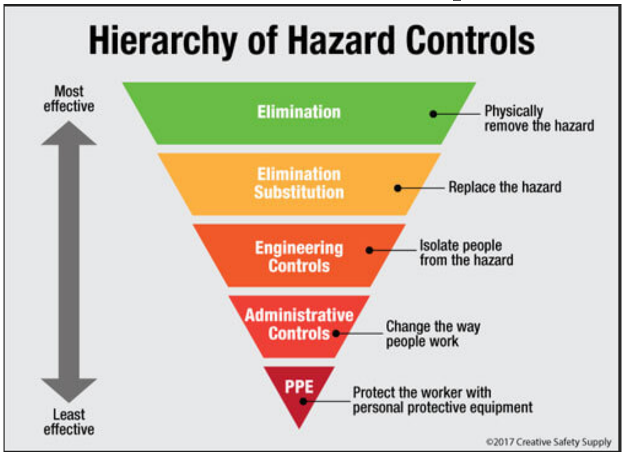

Figure 1 OSHA Hierarchy of Hazard Controls

4.3.1. Elimination

When feasible, this is the best (and preferred) method of controlling risk as it completely removes the hazard from the work area. It also reduces the usage of hazardous chemicals and supports UTK's EC-003 Hazardous Waste Reduction Plan.

4.3.2. Substitution

Another form of elimination, substitution replaces the hazard with a safer alternative. Substitution may include the chemical(s) and/or specific procedural steps.

4.3.3. Engineering Controls

A direct way of reducing exposure can be accomplished by isolating the source or removing contaminants through various ventilation methods. Engineering controls must be implemented within the laboratory whenever practical to minimize exposure to hazardous chemicals.

Chemical Fume Hoods

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, and some powders (risk-dependent). Laboratory workers rely heavily on these, often while performing the most hazardous tasks. **Appendix C** provides information on the proper use of fume hoods.

Due to the importance placed on fume hoods, the following requirements are emphasized:

- Laboratory workers must understand how to use chemical fume hoods properly. PIs need to ensure that workers have received the proper training, and document that training for laboratory safety records.
- It is important that laboratory workers ensure their fume hoods are compatible to the type of chemical that will be used in the fume. For example, hot concentrated acid work may need to be performed in a high-density polyethylene fume hood equipped with a scrubber unit; whereas cold concentrated acid can be handled in a conventional fume hood.
- Fume hood flow testing is performed annually by UTK EHS. After flow testing, a sticker is affixed to each fume hood, which lists the most recent test date. Fume hoods with a test date greater than one year must be put out of service until retesting is complete (if fume hood flow testing date is more than one year old, contact EHS for retesting at 865-974-5084 or ehs_labsafety@utk.edu).

- Fume hoods must be tested by the user(s) 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 EHS at 865-974-5084 or ehs_labsafety@utk.edu, or the UT Facilities Services One-Call at 865-946-7777, if any issues with the fume hoods have been detected.
- Fume hood alarms should never be disarmed.
- Working with perchloric acid poses a unique risk due to the possible buildup of potentially explosive perchlorate residues on surfaces and in ductwork. For this reason, special fume hoods with a water wash-down system have been designed for use with perchloric acid. The wash down system must be used after each operation. A specially designated perchloric acid fume hood must be used if any of the following is applicable:
    - Concentrations > 72% are used (note: concentrations < 60% should be used whenever possible);
    - 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).

Contact EHS at 865-974-5084 or ehs_labsafety@utk.edu for assistance with identifying/locating fume hoods that are suitable for perchloric acid use.

Depending on the risk(s), other ventilation methods, including general room ventilation, point source exhaust (such as snorkels), and gas cabinets may be used to provide protection to workers. Glove boxes, glove bags, pressure relief valves, automatic shut-offs, and air monitors are routinely used as well.

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. At a minimum, ensure that air is flowing or gauges are working. Some controls are more complicated and may require routine maintenance or calibration by outside vendors.

Contact EHS at 865-974-5084 or ehs_labsafety@utk.edu for assistance in determining (or verifying) appropriate engineering controls, operational concerns, and/or equipment malfunction.

4.3.4. Administrative Controls

Administrative controls consist of policies and procedures developed to improve the safety of laboratory operations. Typical examples include restrictions on working alone, nighttime work hours, and experimental scale-up reactions. Since administrative controls require lab personnel to follow appropriate procedures, they are generally not as reliable as engineering controls. These controls must be set by individual PIs or departments. If not already documented in departmental safety plans, then administrative controls must be documented in LS-CHPs or within an SOP for procedure-specific controls. All laboratory members must be informed of these controls.

4.3.5. Personal Protective Equipment (PPE)

Elimination, substitution, 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 chemical splash goggles, face shields, safety glasses*, lab coats, gloves, and respirators. The PI has the primary responsibility to determine the appropriate PPE, ensure that it is made available, and train personnel on its proper use (Appendix E provides a checklist for PPE training and documentation). Details are important. If respirators are required, specific types of respirators must be indicated. The same is true for gloves as chemical compatibility plays a major role in determining the type of glove (e.g., latex, nitrile, vinyl). The Laboratory Safety Manual provides guidance on PPE choices. Additional information can be found on SDSs, which often provide information on the proper choice. UTK EHS can provide assistance on proper choices for PPE. The EHS office shall be contacted at 865-974-5084 or ehs_labsafety@utk.edu to determine the need for and the proper selection, training, and use of respirators.

***Note**: Safety glasses provide frontal protection only from particulate projectiles. 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 vapors.

The PPE required for general lab requirements, specific procedures and tasks must be established through hazard assessment and/or laboratory requirements and be reflected in the LS-CHP. SOP templates available on the EHS website provide a means to document the requirements.

4.4. Safety Showers, Eyewashes, and Fire Extinguishers

Safety showers and eyewashes are essential protective elements for laboratories. 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 UTK Safety Showers and Eyewashes safety guide references the ANSI standard Z358.1, Emergency Eyewash and Shower Equipment, which indicates that eyewashes and showers:

- Must be located within 10 seconds travel time or 55 feet of travel distance of the hazard, 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 and portable eyewash units may support, but not replace, approved eyewashes and showers.

Safety showers and eyewashes are inspected annually by UT Facilities Services. If you have any questions concerning the requirements for eyewashes and safety showers, or how to properly use them, contact EHS at 865-974-5084 or ehs_labsafety@utk.edu.

The EHS Fire Safety unit manages campus fire extinguishers. This group provides, installs, and inspects all necessary fire extinguishers. While the fire extinguishers provided work for most situations, specific laboratory operations may require special extinguishers (e.g., those involving flammable metals). Special use fire extinguisher needs should be identified as part of your laboratory hazard assessment. Please contact EHS at 865-974-5084 or ehs_labsafety@utk.edu for assistance with fire extinguisher assessments.

4.5. Particularly Hazardous Substances (PHS)

OSHA regulations require that provisions for additional employee protection be made for work with particularly hazardous substances (PHS), which 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 PHS must be identified by the PI or laboratory worker designing the experiment or procedure. See **Appendix D** for more information on PHS. Use of any PHS requires:

- Establishment of a designated area;
- Use of appropriate containment devices such as fume hoods or glove boxes dedicated for PHS use only;
- Procedures for safe removal of contaminated waste;
- Decontamination procedures;
- An SOP detailing the material and/or procedural controls.

The room or area where work with PHS is performed must be posted with a ***Designated Area*** sign to identify higher health risks. 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 PHS must be documented in the LS-CHP. The SOP template found in the LS-CHP template (see Appendix A-Section 4) provides a means to document the controls.

4.6. Standard Operating Procedures (SOPs)

An SOP as defined by the Lab Standard is a document that identifies the hazards and risks associated with a process, chemical, equipment, or practice, and the controls and countermeasures employed to eliminate or mitigate the hazards(s).

SOPs must be prepared for PHS and highly reactive chemicals (substances), including:

- Carcinogens
- Reproductive toxins/teratogens
- Acutely toxic chemicals
- Air-reactive (pyrophoric) chemicals
- Water-reactive chemicals
- Self-reactive chemicals
- Explosives

Additionally, high-risk procedures that require special work practices and safety considerations require an SOP. Examples include, but are not limited to, working with large volumes of highly flammable (Class IA or Class IB) or corrosive chemicals, scale-up procedures, working with pressurized vessels or vacuums, etc.

There are many different ways to incorporate safety practices into the lab SOPs. The objective is to identify the hazards, describe necessary safety practices (e.g. “work with tamoxifen will only be done in the fume hood”) and personal protective equipment (e.g. “nitrile gloves will be worn any time you work with osmium compounds”). To assist with this, a SOP Procedure Form is available in the LS-CHP template (see **Appendix A, Section 4**). Other formats may be acceptable provided that they emphasize the hazards, risks, and controls as required by the Lab Safety Standard.

SOPs involving PHS, reactive chemicals, and/or high-risk procedures may require review and approval from EHS and/or designated safety committees (e.g. HHCRC).

4.7. Prior Approvals

The nature of the work performed in laboratories on campus varies widely. PIs must ensure that a risk assessment is performed for all activities involving hazardous substances. Certain procedures or conditions may be considered hazardous enough that these should only be performed with prior documented approval from the PI. Examples include, but are not limited, working alone (or off-hours work), scaling up reactions, or introducing new materials or reaction steps, particularly involving PHS or other high-risk materials (e.g.

hydrofluoric acid, pyrophoric chemicals, etc.). In some cases, additional approvals from EHS and/or designated safety committees (e.g. HHCRC) may be required.

5.0 Hazard Communication

OSHA chemical safety regulations require communication of the potential hazards to which a worker may be exposed. UTK approaches to meeting this requirement are described in this section.

5.1. Chemical Hygiene Plans (CHP)

OSHA regulations require the development of a CHP, 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 UTK CHP and Laboratory Safety Manual meet many of the requirements. However, each laboratory has a specific chemical inventory and accompanying procedures, equipment, etc. Therefore, UTK requires a LS-CHP, to be created by the PI or trained and knowledgeable designate, in order to be in full compliance. Additionally, the UTK CHP, LS-CHP, and Laboratory Safety Manual must be readily available to laboratory workers and worker representatives. These documents should be placed in a location that is readily accessible to all workers or made available electronically (e.g. network drive).

5.2. Safety Data Sheets and Other Safety Information

A SDS is prepared by the manufacturer and summarizes the physical and chemical characteristics, health and safety information, handling, and emergency response recommendations related to its products. The SDS must 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 in case of emergencies. The International Fire Code (IFC), which has been adopted by the Knoxville Fire Department (KFD), 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 chemical literature or chemical safety references such as the National Research Council's Prudent Practices in the Laboratory, as necessary. These resources should be made available to laboratory staff.

5.3. Exposure Monitoring Results

In certain instances, UTK EHS may measure laboratory worker exposure to a chemical regulated by a specific OSHA standard. The PI must notify the laboratory staff of monitoring results in writing, either individually or by posting results in an appropriate location that is accessible to employees, within 15 working days. 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 a 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 chemical name, and where appropriate the primary hazard (e.g. flammable, reactive, corrosive, etc.). It is acceptable to use one label for a rack containing individual vials of the same chemical. All laboratory personnel must be trained in the hazard communication method that is employed.

5.5. Laboratory Door Placards

In addition to workers, emergency first responders, such as firefighters, police officers, and paramedics, must be informed of the hazardous chemicals present in a laboratory. Laboratory door placards provide this valuable information. Resultantly, EHS requires door placards to be reviewed and updated annually. Additional information can be obtained at:

https://ehs.utk.edu/index.php/laboratory-safety/lab-safety-administration/lab-door-placards/.

6.0 Chemical Storage and Inventory

Use and storage of hazardous chemicals is regulated by federal, state, and local regulations. These regulations, including OSHA worker protection standards, emergency response and planning regulations, and local building and fire codes, limit the amount of materials that can be used and where they can be used or stored. They also require chemical inventories to be available for emergency planning and response.

6.1. Chemical Storage and Use Limitations

Per requirements of the KFD and the Knoxville Fire Prevention Code, UTK must meet the requirements outlined in the IFC. Additionally, 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, and other high-risk materials. In some cases, control areas may be required. Below are some of the key requirements for storage of chemicals at UTK. This list is not comprehensive and does not include many of the prudent safety practices included in the Laboratory Safety Manual or the guidance documents found on the EHS website at https://ehs.utk.edu.

6.1.1. Chemical Compatibility and Safe Storage

In addition to chemical storage limitations imposed by regulations and codes, the PI is responsible for following prudent storage practices of chemicals. These include, but are not limited to:

- Storing chemicals in designated areas (e.g. flammables in a flammable storage cabinet);
- Ensuring that bottles (or other containers) are compatible with the stored chemical(s), securely closed and appropriately labeled;
- Using secondary containers to guard against breaks, leaks, spills, particularly for chemicals stored near or on the floor;
- Grouping chemicals according to their hazard category (i.e. strong acids, strong bases, oxidizers, flammables, pyrophorics, self-reactives, etc.);
- Separating incompatible chemicals (e.g. oxidizers and organic acids, or oxidizers and flammable liquids, must not be stored together);
- Storing corrosive chemicals below eye level;
- Keeping only minimal amounts of acutely toxic substances and storing them in securely locked cabinets;
- Disposing of unstable compounds (such as peroxide formers) upon their indicated expiration date.

The Laboratory Safety Manual outlines additional principles to be followed. For assistance in determining appropriate storage locations/conditions, chemical compatibility, etc., contact EHS at 865-974-5084 or ehs_labsafety@utk.edu.

6.1.2. Flammable Liquids

The following university limitations have been set on flammable liquids (in instances where the building limits are more stringent, those limits will apply):

- No more than 10 gallons of flammable liquids per typical laboratory may be stored outside an approved flammable storage cabinet, with exceptions made for materials stored in approved safety cans. Exceptions may be made for larger laboratory suites depending on risk assessment; however, volumes must not exceed fire code limits;
- No more than 60 gallons of Class I or Class II flammable liquids, or no more than 120 gallons of Class III flammable liquids, many be stored in a flammable storage cabinet.
- If refrigeration is required, flammable liquids 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 EHS for additional information.

Additional information can be found in the Laboratory Safety Manual, the UTK Use and Storage of Flammable & Combustible Liquids guidance document, or by contacting EHS at 865-974-5084 or ehs_labsafety@utk.edu.

6.1.3. Compressed Gas Cylinders

In order to ensure safe use and storage, all gas cylinders must be:

- Stored within a well-ventilated area, and away from damp areas, salts or corrosive atmospheres, and 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 inches tall may be secured by approved stands or wall brackets. The number of cylinders shall not exceed restraint limits;
- Capped when not in use or attached to a system (if the cylinder will accept a cap);
- Separated from incompatible gas cylinders (e.g. flammable compressed gases and oxygen) by a minimum of 20 feet. Storage areas that have a noncombustible wall at least 5 feet 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.

Due to the hazards posed by highly toxic, corrosive, and pyrophoric gases, all procedures involving these gases must be reviewed by EHS and/or relevant safety committees (e.g. HHCRC) prior to use. Additional requirements for safe handling of gas cylinders can be found in the Laboratory Safety Manual, the UTK Compressed Gases and Cryogens guidance document, or by contacting EHS at 865-974-5084 or ehs_labsafety@utk.edu.

6.1.4. Cryogenic Liquids

Cryogenic liquids may displace oxygen, leading to oxygen-deficient atmospheres. Safety precautions for handling or storing cryogenic liquids include:

- 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 may not be required, contingent upon EHS approval.
- Indoor areas where cryogenic liquids in any quantity are dispensed in areas with adequate mechanical or natural ventilation. Vapors should be captured at the point of generation whenever feasible. If it can be demonstrated that there is no risk of oxygen depletion or harmful vapors then ventilation may not be required, contingent upon EHS approval.
- Cryogenic usage that indicates a possibility of creating a hazardous situation may require additional signage, ventilation, and monitoring.

Additional information on cryogen storage and handling can be found in the Laboratory Safety Manual, the UTK Compressed Gases and Cryogens guidance document, or by contacting EHS at 865-974-5084 or ehs_labsafety@utk.edu.

6.2. Chemical Inventories

6.2.1. Regulations

In addition to satisfying the OSHA Laboratory Standard, chemical inventories must be kept to ensure compliance with the several regulations including the following

1.1.1.1 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, local emergency planning committees, and in some cases the local fire department. EPCRA has four major provisions that are largely independent of each other and involve different chemical lists with different threshold reporting quantities.

1.1.1.2 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. Approximately 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 has completed the initial security screening, but any significant changes to the UTK inventory must be reported to DHS.

1.1.1.3 Knoxville Fire Codes

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

6.2.2. UTK Inventory Management System (BioRAFT)

Laboratory chemical inventories are to be entered and maintained in the EHS electronic laboratory management system (BioRAFT). Chemical inventories are to be reviewed and updated whenever new chemical hazards are introduced into the laboratory and at least annually. Information, login instructions, tutorials and guides are available at https://ehs.utk.edu/index.php/bioraft/. For additional assistance, contact EHS at 865-974-5084 or ehs_labsafety@utk.edu.

7.0 Department of Health & Human Services (DHHS) Select Biological Toxins

The Public Health Security and Bioterrorism Preparedness and Response Act of 2002, Subtitle A of Public Law 107–188 requires the DHHS 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 Table 1, are regulated if inventory levels exceed, at any time, the amounts indicated. Users that anticipate exceeding the listed thresholds must register with the federal Select Agent Program. Unregistered individuals exceeding these limits face severe federal penalties. 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 authorized personnel. The toxin inventory logs will be reviewed by the UTK Biosafety Program at least annually. Use of biological toxins must also be included in biosafety protocols and approved by the UTK Institutional Biosafety Committee.

Table 1. Select Toxins and Permissible Quantities

HHS Toxins [§73.3(d)(3)]	Amount
Abrin	1000 mg
Botulinum neurotoxins	1 mg
Short, paralytic alpha conotoxins	100 mg
Diacetoxyscirpenol (DAS)	10,000 mg
Ricin	1000 mg
Saxitoxin	500 mg
Staphylococcal Enterotoxins (Subtypes A, B, C, D, and E)	100 mg
T-2 toxin	10,000 mg
Tetrodotoxin	500 mg

Questions concerning biological toxins should be directed to the UTK Biosafety Program at 865-974-5084 or utbiosafety@utk.edu.

8.0 Standard Pharmaceuticals and Drugs Used to Elicit a Biological Response

Use of FDA-approved pharmaceuticals or experimental drugs in a clinical setting is outside the purview of this document. However, the safe handling and use of pharmaceuticals and drugs in a laboratory setting must be described in the LS-CHP if the drug has the characteristics of PHS (i.e. carcinogen, reproductive toxin, or acutely toxic) and is in a form that has the potential to lead to an exposure. Likewise, use of any hazardous chemical for eliciting a biological response must be covered by the LS-CHP.

When such chemicals, pharmaceuticals or drugs are used in an animal model, it is the responsibility of the PI 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; and
- First aid response in the event of an exposure.

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 where pain medication is required.

Use of controlled substances for research requires obtaining both federal (DEA) and state (TN State Board of Pharmacy) approvals. 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 include:

- 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 since administration of expired controlled substances is not disallowed per the U.S. Department of Agriculture Animal Welfare Act (and other animal welfare agencies);
- Disposal is strictly regulated. Only the DEA Special Agent in Charge can authorize the disposal of controlled substances.
- Sewer disposal of any DEA drug is prohibited. Contact EHS for additional guidance regarding disposal.

EHS has no role in the permitting process or compliance with issued approvals, though it can provide limited guidance and facilitate disposal coordination upon request. EHS ***may not*** take possession of controlled substances waste for disposal on behalf of the researcher.

10.0 Surplus Chemicals and Hazardous Waste Management

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. EPA and is promulgated in Tennessee by the TDEC.

Because UTK is not allowed to treat hazardous chemical waste onsite, all chemical waste must be submitted to the EHS Waste Management Program for disposal through a hazardous waste contractor. EHS has designated specific locations and times for waste to be collected. The waste collection schedule, and other waste management details, can be found in the UTK *Hazardous Waste Management Plan*.

10.1. Hazardous Waste Reduction

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 recycling, fuel-blending, thermal recovery, and waste-to-energy programs. To the extent feasible, researchers should assist with waste minimization through experimental planning, reduction of experimental scale, and procurement management (see the American Chemical Society's "*Less is Better*" guidance document). Additional information regarding waste minimization may be found in the UTK Hazardous Waste Reduction Plan.

10.2. 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" (SAAs), and each laboratory is allowed one SAA (per room). 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 established limit is met, the laboratory staff has 72 hours to have the container transferred to an official UTK hazardous waste storage area.
- As soon as waste collection begins, containers must be marked with the required UTK yellow hazardous waste label (contact EHS at 865-974-5084 or ehs_labsafety@utk.edu for waste labels). The label must include the full chemical names of all waste constituents as well as approximate final volumes (percentages). **It is especially important to label containers holding waste mixtures with the contents to prevent unexpected reactions, which can lead to explosions or release of toxic gases**.
- Containers must be kept with lids closed, except when adding or 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 SAAs must be trained in waste handling and management, emergency procedures and other topics specific to that area. Training includes the UTK EHS hazardous waste programmatic training (available through Canvas) as well as laboratory- specific training.

10.3. Laboratory Cleanouts and Clean Sweeps

UTK EHS 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. Contact EHS at 865-974-5084 or ehs_labsafety@utk.edu for additional information

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. EHS provides various courses and classes to meet these needs. EHS 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 PI (personally or by a designated staff member or outside source). The PI 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. The OSHA Laboratory Standard can be accessed at https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.1450;
- The location and availability of the UTK CHP, the LS-CHP, and the Laboratory Safety Manual;
- 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 B 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, including, but not limited to, SDSs received from the chemical supplier;
- Safe handling, storage, and disposal of hazardous chemicals found in the laboratory.

11.2. Training

UTK EHS offers regularly scheduled training on general laboratory safety. This covers details of the OSHA Laboratory Standard as well as campus safety policies (including the UTK CHP), resources, and services. For additional training information, contact the EHS office or visit the EHS website at https://ehs.utk.edu/index.php/laboratory-safety/lab-safety-training/.

Laboratory staff must also receive training from their PI, or designee, 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, etc.).

Training must be communicated in a manner readily understood to those being trained. This may require written as well as oral transmission of information. Unless otherwise indicated by EHS, the frequency of refresher training and information can be determined by the PI. Refer to the LS-CHP template for information on laboratory-specific documentation requirements.

12.0 Emergency Response

Each PI must ensure that laboratory staff are knowledgeable and trained on emergency procedures. Many of the procedures are covered in other campus plans, including the Building Emergency Action Plan (BEAP). The BEAP is an all-hazard plan designed around a building's unique layout and function. The primary purpose of the BEAP 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 (see **Appendix F**);
- Procedures for responding to fires;
- Procedures for responding to power failures;
- 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 door placard (located near the laboratory entrance) and make sure the information is up-to-date. Keep your SDS files updated 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, ensure that emergency spill kits are appropriate for the chemical hazards in the lab (e.g. flammable solvent spill kits are inadequate for neutralizing caustic acid or base spills).
- Have emergency contacts posted (see **Appendix G**):
    - UT Police: 911 or 865-974-3111 (Emergency)
      Dialing 911 on a landline phone or cell phone will connect you to the Knox County 911 Call Center.
    - Environmental Health and Safety 865-974-5084

13.0 Exposure Monitoring

The State of Tennessee regulations require exposure monitoring where exposure may occur at or above a published PELs indicated by OSHA for established health standards. EHS will assist in determining exposure potential and methods of exposure monitoring. If it is determined that PELs have been exceeded, affected personnel will be referred to UTK occupational health staff to evaluate according to the established standard. Monitoring results will be communicated within 15 days of receipt (see Section 5.3).

14.0 Respiratory Protection

Whenever possible, exposures to hazardous chemicals must be minimized through 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. The EHS office shall be contacted at 865-974-5084 or ehs_labsafety@utk.edu to determine the need for and the proper selection, training, and use of respirators.

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, conducting a medical evaluation and respiratory fit testing, and receiving training on the proper use of respirators.

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 (or other injuries);
- 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 that may put you at greater risk. Contact EHS for more information regarding occupational health options.

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

- 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 any signs and symptoms of exposure that the worker is experiencing.

16.0 Laboratory Audit Program

The laboratory audit program is an ongoing program that provides laboratories with EHS assistance and consultation to help create a safe work environment. As part of the visit, EHS staff will help ensure that the obligations of all institutional policies and governmental regulations are met. EHS 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 PI and/or designated laboratory manager. Department heads and DSOs will be copied on the report as requested. This report outlines laboratory successes, opportunities for improvement, safety/compliance findings and respective corrective actions. Guidance documents or other reference materials will be included in the report as necessary. EHS staff are available to assist in making improvements.

EHS staff visit laboratories annually by department (or building, if appropriate) on a rotating basis. However, EHS staff are available to visit any laboratory at any time upon request.

17.0 Incident/Accident Notification Investigation

In addition to UT Risk Management reporting, PIs 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 EHS by calling 865-974-5084 or emailing ehs_labsafety@utk.edu as soon as possible.

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 EHS staff with the primary goals of 1) understanding why the accident or near miss occurred; 2) determining what actions can be taken to prevent recurrence; and 3) sharing lessons learned with stakeholders.

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;
- Tracking the findings to timely closure and recording corrective actions taken;
- Sharing lessons learned.

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 the EHS staff performing the investigation. Where appropriate, findings and lessons-learned will be communicated with University administration, the LSC, DSOs, and/or faculty.

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 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.

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.

The requirements can be found in 49 CFR Parts 171-178, which covers the documentation, packing, marking, and labeling of hazardous materials. The 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 be met. In addition to proper packaging and labeling, the regulations require that the individual receive training that must be refreshed at a minimum of every three years (two years for IATA) or when the regulations change significantly.

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 up to 10 years imprisonment. **Consequently, EHS must be contacted at 865-974-5084 or ehs_labsafety@utk.edu prior to shipping any hazardous (or potentially hazardous)**

material. EHS will assist with identification, packaging, labeling and paperwork to ensure compliance with applicable shipping regulations.

***Important**: With few exceptions, no hazardous 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 and to communicate this information to laboratory members.*

18.2. On-Campus Transportation of Hazardous Materials

Under the current regulations, UTK is considered a government agency and is exempted from some aspects of the DOT regulations; therefore, *with the approval of EHS*, university employees may transport *some* types of hazardous materials for UT-related purposes. Transport should be limited to short distances (between campus buildings or adjacent campuses) and small volumes and adhere to the following:

- The employees involved in moving the hazardous material 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;
- Primary and secondary containers must be appropriately labeled with the contents and appropriate precautionary statements (e.g. flammable, corrosive, etc.);
- 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 Knoxville Area Transit (KAT) or UT shuttle bus. These could include but are not limited to: flammable liquids; dangerous, toxic or poisonous substances; or vessels containing caustic materials, acids or alkalis.

EHS will coordinate the movement of large quantities of chemicals between buildings.

Hazardous waste is regulated by the US EPA in 40 CFR 260-265. The transportation of hazardous waste requires special marking, training, and documentation. Hazardous waste can only be transported by UTK EHS employees and approved contractors.

19.0 Records

PIs are required to maintain all records associated with their laboratories. These records include:

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

Laboratory-associated records should be maintained in EHS-designated electronic management systems (e.g. BioRAFT) whenever possible.

20.0 Definitions and Abbreviations

20.1. 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 a boiling point 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 that produces a lethal dose or lethal concentration as follows:

1. A chemical that has a median lethal dose (LD50) 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 (LD50) 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 (LC50) 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 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 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 unstable compounds over 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 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.
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 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 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.

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 1. Materials that in themselves are normally stable but which can become unstable at elevated temperatures and pressure.
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 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 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.

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

20.2. Abbreviations

ACGIH: American Conference of Governmental Industrial Hygienists
BBP: Bloodborne Pathogens
CHO: Chemical Hygiene Officer
CHP: Chemical Hygiene Plan
COI: Chemicals of Interest
CSA: Controlled Substance Act
D-CHP: Departmental Chemical Hygiene Plan
DEA: Drug Enforcement Agency
DHHS: Department of Health & Human Services
DHS: Department of Homeland Security
DOT: Department of Transportation
EHS: Environmental Health & Safety
EPCRA: Emergency Planning and Community Right-to Know Act
HHCRC: High-hazard Chemical Review Committee
IATA: International Air Transport Association
IBC: International Building Code
IDLH: Immediately Dangerous to Life or Health
IFC: International Fire Code
KFD: Knoxville Fire Department
LSC: Laboratory Safety Committee
LS-CHP: Laboratory-specific Chemical Hygiene Plan
MAQ: Maximum Allowable Quantity
NFPA: National Fire Protection Association
OSHA: Occupational Safety and Health Administration
PEL: Permissible Exposure Level
PHS: Particularly Hazardous Substance
PI: Principal Investigator
PPE: Personal Protective Equipment
QLD: Qualified Laboratory Designate
REL: Recommended Exposure Limit
SAA: Satellite Accumulation Area
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
UTK CHP: University of Tennessee, Knoxville Chemical Hygiene Plan
WWEL: Workplace Environmental Exposure Level

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 basis. These limits still perform a needed function in aiding an informed risk assessment process. Below is a brief description of 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 PEL. Most OSHA PELs are based on an 8-hour work shift of a 40-hour workweek 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 that should not be exceeded over a 15-minute period. To locate PELs on specific chemicals go to: 29 CFR 1910.1000 TABLE Z-1.

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). Additionally, 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.

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 reactivity, 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://aiha.org/get-involved/aiha-guideline-foundation/weels.

Appendix C:
Chemical Fume Hoods

Fume hoods (see **Figure C1**) and other capture devices must be used for operations that might result in the release of toxic chemical vapors, fumes, or dusts. Bench top use of chemicals that present an inhalation hazard is not recommended. Fume hoods should be used when conducting new experiments with unknown reaction consequences or when the potential for a fire exists.

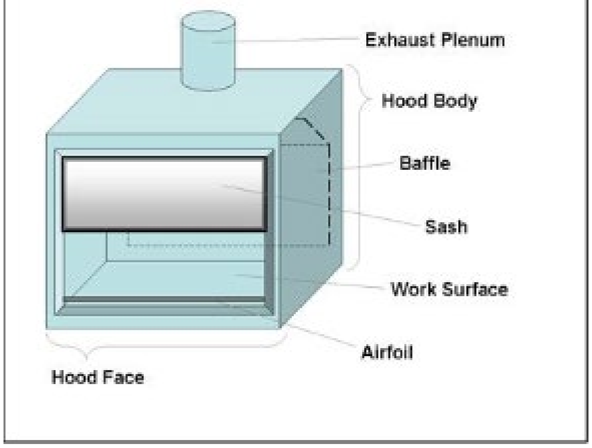

Figure C1. Fume Hood Schematic 1

To obtain optimum performance and achieve the greatest protection when using a fume hood, please adhere to the following:

Training, Knowledge and Understanding

- **Be aware of the limitations and compatibilities of your fume hood(s)**.

Ensure Working Order

- Before using a fume hood, ensure the fume hood is working by checking for the presence of airflow. This can be done by taping a piece of tissue paper (Kimwipe®) to the lower edge of the sash and visually checking that there is enough airflow to draw the tissue to the interior of the fume hood (note: do not release the tissue into the fume hood as it may get sucked into the exhaust and cause maintenance issues).
- **Do not** use an improperly working fume hood. If EHS or Facilities Services has posted the hood as being out of service, the flow may not protect your breathing zone from a harmful exposure to hazardous materials.
- Report any malfunctioning fume hoods to your supervisor, DSO, and EHS immediately. If the fume hood is not working properly, then let other people in the lab know by placing a "DO NOT USE" sign on the hood.
- **If the fume hood is not working properly, close the sash and report the malfunction to EHS at 865-974-5084 or Facilities Services at 865-946-7777.**
-

Operation

- Keep the fume hood sash lowered at all times to a height appropriate for the user to prevent inhalation of materials. The sash height should be approximately equal to the height of the users elbow to minimize sash height without compromising mobility. Typically, this is between 10" and 18".
- Whenever the fume hood is not being used, keep the fume hood sash closed all of the way to contain hazards inside the hood and to conserve energy. Note that the fume hood sash serves as a fire/explosion barrier should an unplanned and violent reaction occur inside the hood.
- Keep materials stored in hoods to a minimum to reduce clutter. Excess and unnecessary storage and clutter results in decreased hood performance and increases the chances of an accident or spill. Do not use hoods as storage cabinets, especially for long-term storage of chemicals and hazardous waste.

- Place chemical/hazardous waste containers that are stored temporarily in the fume hood in secondary containment (trays, tubs, butyl rubber bottle carrier etc.)
- For optimum performance of the fume hood, keep all materials and equipment back at least six (6) inches from the face of the hood and do not block the vents or baffle openings in the back of the hood.
- Keep any lab equipment elevated at least two (2) inches off the work surface of the hood to allow for proper airflow. Use bench stands or items such as metal test tube racks or other non-combustible items that will not react with the chemicals in use.
- When working in a fume hood, keep windows and doors closed within the lab and minimize traffic in front of the hood. Minimize rapid movements while working in the hood, including opening and closing the sash. All of these precautions will help to prevent air currents from forming, which can result in hazardous vapors being pulled out of the hood and into the laboratory personnel's breathing zone.
- Run equipment cords, hoses and tubing under the fume hood foil and then up onto the fume hood's surface whenever feasible. This will allow you to fully close the sash and minimizes pinch points on cords & tubing/hoses.
- Do not use fume hoods to evaporate hazardous waste. Evaporating hazardous waste is illegal.
- For procedures involving particularly hazardous substances or chemicals that can form toxic vapors, fumes, or dusts, the hood or equipment within the hood may need to be fitted with condensers, traps, or scrubbers in order to prevent the vapors, fumes, and dusts from being released into the environment. Contact EHS at 865-974-5084 or ehs_labsafety@utk.edu for assistance in determining fume hood configurations.
- When pouring flammable liquids, always make sure both containers are electrically interconnected to each other by bonding and grounding in order to prevent the generation of static electricity – which can cause the flammable liquid to ignite.
- As with any work involving chemicals, always practice good housekeeping and **clean up all chemical spills immediately**. Be sure to wash both the working surface and hood sash frequently and always maintain a clean and dry work surface that is free of clutter.

General Rules for Fume Hood Use

The following general rules should be followed when using laboratory hoods:

1. Fume hoods should not be used for work involving hazardous substances unless they have a inspection label that confirms airflow testing has occurred within the past year.
2. Always keep hazardous chemicals >6 inches behind the plane of the sash.
3. **Never** put your head inside an operating laboratory hood. The plane of the sash is the barrier between contaminated and uncontaminated air.
4. Work with the hood sash in the **lowest practical position**. The sash acts as a physical barrier in the event of an accident. Keep the sash closed when not conducting work in the hood.
5. Do not clutter your hood with unnecessary bottles or equipment. Keep it clean and clear. Only materials actively in use should be in the hood.
6. Do not make any modifications to hoods, ductwork, or the exhaust system without first contacting the EHS office at 865-974-5084 or ehs_labsafety@utk.edu.
7. Do not use large equipment in laboratory hoods unless the hood is dedicated for this purpose, as large obstructions can change the airflow patterns and render the hood unsafe.
8. **Shut your sash!** For safety, accident prevention, and energy efficiency, make sure to shut your sash when the hood is not in use.

Perchloric Acid Use

Be aware that use of heated perchloric acid requires a special perchloric acid fume hood with a wash-down function. DO NOT use heated perchloric acid in a regular fume hood. If heated perchloric acid is used in a regular fume hood (without a wash down function), shock sensitive metallic perchlorate crystals can form inside the duct work, and could result in causing an explosion during maintenance work on the ventilation system. If you suspect your fume hood has perchlorate contamination or would like more information on perchloric acid fume hoods, contact EHS at 865-974-5084 or ehs_labsafety@utk.edu.

Fume Hood Inspection and Testing Program

EHS coordinates annual testing and inspection of fume hoods on campus. After each inspection, the fume hood inspection sticker is completed. DO NOT use the fume hood if it does not have an inspection sticker or if the existing inspection sticker on your fume hood indicates a year or more has passed since the hood was last inspected. Contact EHS at 865-974-5084 or ehs_labsafety@utk.edu to conduct airflow testing.

Other Capture Devices

Other engineering controls for proper ventilation include glove boxes, compressed gas cabinets, vented storage cabinets, canopy hoods, and snorkels. These pieces of equipment are designed to capture hazardous chemical vapors, fumes, and dusts at the source of potential contamination. Examples where these capture devices would be appropriate include welding/soldering operations, atomic absorption units, vacuum pumps, inductive coupled plasma units and other operations.

Please note, when other laboratory apparatuses (such as vacuum pumps and storage cabinets) are vented into the face or side of a fume hood, disruptions can occur in the design flow of the hood and result in lower capture efficiency. When such venting is deemed necessary, the connection should be further along the exhaust ducts of the hood system rather than into the face of the hood. DO NOT alter the fume hood to accommodate research needs (ex.: cut hole in fume hood side to connect a vent hose) as this may disrupt the fume hood efficiency and invalidate manufacturer's warranty.

To avoid the possibility of disrupting the efficiency and operation of the fume hood, any additional installations or adjustments should not be undertaken without first consulting Facilities Services and EHS.

Appendix D:
Particularly Hazardous Substances

When working with hazardous materials, laboratory personnel need to understand the risks associated with these 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 (PHS) since these substances potentially pose a higher health risk. PHS are, according to OSHA, select carcinogens, reproductive toxins, substances that have a high degree of acute toxicity.

The OSHA requirements for working with PHS 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 as necessary.

Laboratory personnel must do their due diligence in determining hazards when planning an experiment or procedure. This appendix provides some information and links to resources that help you identify PHS. It is impossible to provide a master list of all PHS so the information below should not be assumed to be comprehensive. This is especially true at a research institution where exotic materials lacking toxicological information are often used. Additionally, toxicity is often related to a chemical's physical state as well as how it is used. For example, compounds that 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 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). UTK EHS guidance on reproductive toxins can be found at https://ehs.utk.edu/index.php/table-of-policies-plans-procedures-guides/reproductive-health-guidelines/.

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". According to OSHA, a chemical falling within any of the following categories is considered 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 in **Table D1** 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, particularly the CHO/EHS, whenever possible. The SDS should also be consulted as it often has GHS or NFPA health ratings for the compounds.

Table D1. List of Highly Toxic Compounds

Table D1. List of Highly Toxic Compounds

Compound name	***CAS #***
ACETONE CYANOHYDRIN (DOT)	75-86-5
3-(ALPHA-ACETONYLBENZYL)-4-HYDROXYCOUMARIN	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

Table D1. List of Highly Toxic Compounds

Compound name	***CAS #***
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

Table D1. List of Highly Toxic Compounds

Compound name	***CAS #***
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

Table D1. List of Highly Toxic Compounds

Compound name	***CAS #***
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 E:
Personal Protective Equipment (PPE) Certifications

The form for PPE training and certification can be found at the end of this section. OSHA requires the following PPE training certification elements:

1. When PPE is necessary;
2. What PPE is necessary;
3. How to properly don, doff, adjust, and wear PPE;
4. The proper care, maintenance, useful life and disposal of the PPE;
5. The proper cleaning and storage of PPE;

The following form must be filled out for every lab member that is required to wear any type of PPE as determined by the laboratory-specific hazard assessment.

A copy of each certification form shall be maintained in your laboratory profile in the EHS-designated electronic management system (BioRAFT).

Appendix G:

Emergency Contact Numbers

Monday-Friday, 8:00 am to 5:00 pm

UTK EHS	865-974-5084
Biological Safety	865-974-1938
Radiation Safety	865-974-5580
UTIA Safety Office	865-974-4904
UT Space Institute Safety Office	931-393-7208
Office of Emergency Management	865-974-3061
Facilities Services	865-946-7777
UT Risk Management	865-974-5409

After Hours, Weekends & Holidays

Knoxville Fire Department	911
UT Police (Emergency Line)	865-974-3111
UT Police (Main Line)	865-974-3114
Campus Information	865-974-1000
Facilities Services One Call	865-946-7777
UT Space Institute Security	931-588-6060