CHEMICAL HYGIENE PLAN
(November 2006)

Department of Chemistry
Vanderbilt University

1.0 INTRODUCTION

The Chemistry Department at Vanderbilt University (VU) has developed and implemented a written Chemical Hygiene Plan (CHP) which complies with applicable regulations under the Tennessee Department of Labor, Division of Occupational Safety and Health (TOSHA) – www.state.tn.us/labor-wfd/tosha.html. The VU Chemistry Department is committed to maintaining employee exposures to hazardous chemicals below established permissible exposure limits (PELs) and threshold limit values (TLVs). In order to accomplish this goal, the CHP is designed to keep all personal exposures to hazardous chemicals to a minimum.

2.0 THE LABORATORY STANDARD

TOSHA adopted the laboratory standard as it was written by the United States Occupational Safety and Health Administration (OSHA), including the numbering (29 CFR 1910.1450). The standard is contained in TOSHA's "Occupational Safety and Health Standards for General Industry." The laboratory standard applies to all employers engaged in the laboratory use of hazardous chemicals. A link to the TOSHA Laboratory Standard and its appendices is provided on the Department website.

In the Chemistry Department at Vanderbilt University, the laboratory standard applies to all laboratories. The laboratory standard will supersede all other TOSHA health standards in 29 CFR part 1910, subpart Z except as follows:

- For any OSHA health standard, only the requirement to limit employee exposure to the specific permissible exposure limit (PEL) shall apply, unless that particular standard states otherwise.
- Prohibition of eye and skin contact where specified by any OSHA health standard shall be observed.
- Where the action level (or in the absence of an action level, the PEL) of a chemical being utilized, is routinely exceeded for an OSHA regulated substance with exposure monitoring and medical surveillance requirements specific exposure monitoring and medical surveillance requirements apply.

3.0 SCOPE AND APPLICATION

This document serves as the written guide for compliance to the TOSHA Laboratory Standard and the Chemical Hygiene Plan (CHP) requirements contained therein. All laboratories (undergraduate and graduate) within the Department of Chemistry at Vanderbilt University engaged in the laboratory use (as defined by this document) of hazardous chemicals are required to comply with this document.

The primary objective of this document is to provide a general guide for handling hazardous chemicals in laboratories. The Chemical Hygiene Plan establishes the basic safety principles for laboratory procedures, equipment and work practices that are

capable of protecting employees from physical and health hazards of hazardous chemicals in laboratories.

This document is intended only to highlight those safety measures necessary for achieving a safe and healthy work environment. Where the scope of hazards is not adequately addressed by this general document, specific Standard Operating Procedures must be developed by the faculty member.

4.0 DEPARTMENTAL SAFETY MANAGEMENT

4.1 Chemistry Safety Committee

The Chemistry Safety Committee is appointed by the Chair of Chemistry. This committee is responsible for developing safety protocols for the Department of Chemistry, administering safety training, developing and maintaining this Chemical Hygiene Plan, auditing Chemistry laboratories for safety issues, and ensuring that all safety deficiencies are corrected in a timely manner. The Chemistry Safety Committee is divided into two tiers – the Administrative Tier and the Student Tier, which are described below.

Administrative Tier

The Chemistry Safety Committee Administrative Tier consists of select faculty and administrators from the Department of Chemistry, including the Department Chair and the Chemical Hygiene Officer, and representatives from Vanderbilt Environmental Health and Safety (VEHS).

Student Tier

The Chemistry Safety Committee Student Tier consists of select Chemistry graduate students. The Student Tier is coordinated by the Chemical Hygiene Officer.

4.2 TRAINING

All faculty, students, and lab workers that perform research work or supervise or manage others that perform research work in chemical laboratories must undergo annual general lab safety training including training on the contents of this Chemical Hygiene Plan. This training will normally be scheduled at the beginning of the fall semester. A sign in sheet will be used to verify attendance and training documentation will be maintained by the Chemical Hygiene Officer.

Additionally, faculty members must ensure that all workers performing research work under their supervision have received training on laboratory-specific procedures and safety rules including the Laboratory-Specific Safety Plan. (See the “Laboratory-Specific Safety Plan” section of this Chemical Hygiene Plan for more information on this topic.)

This training should include the location of material safety data sheets; location, availability, and use of personal protective equipment and emergency response equipment; emergency procedures; and identified hazards in the laboratory including explanations of hazard and warning signs in the lab. This training should be conducted at least annually and should be documented and kept on file by the faculty member. The most current training records for all current lab staff should be maintained. Documentation of lab-specific training should be made available to members of the Chemistry Department Safety Committee audit team upon request.

On-the-job training should be provided as necessary prior to allowing a student or lab worker to begin a new process or use equipment for the first time. Faculty members and lab managers are encouraged to document this training with at least a simple sign-off sheet.

Additional training may be required for special lab processes or work with certain equipment or hazardous materials. Examples include working with radioactive materials or equipment, animals, biological materials, or lasers. Contact VEHS (322-2057; http://www.safety.vanderbilt.edu) for information on training requirements for working with these materials.

Laboratory Requirements

- Annual training on general lab safety and the contents of the Chemical Hygiene Plan is required for all faculty, students, and staff that work in or supervise people that work in chemical laboratories. This training is provided by VEHS and documentation of attendance is maintained by the Chemical Hygiene Officer.
- Faculty members must provide annual lab-specific safety training for all workers performing research under their supervision. This training should be documented and filed by the faculty member.
- Faculty members, lab managers, and/or supervisors must ensure that all lab workers receive on-the-job training prior to performing specific processes or working with lab equipment for the first time.
- Additional specific training may be required for work with radioactive materials or equipment, animals, biological materials, lasers, or other special lab equipment. Contact VEHS (322-2057; http://www.safety.vanderbilt.edu) for information on training requirements for working with these materials.

4.3 CHEMICAL SAFETY PROTOCOLS

Chemical safety protocols (CSP's) are written documents used to describe the safety and health procedures for specific laboratory processes that involve chemical hazards. Processes that do not involve chemical hazards do not require CSP's. A copy of the CSP form and instructions for completing the form are included in Appendix B. The CSP's describe the following information for performing a lab process or using a lab chemical or class of chemicals:

- Potential hazards associated with the process, chemical, or class of chemicals.
- Required personal protective equipment to be used.
- Required engineering controls (such as fume hoods) to be used.
- Special handling or storage requirements.
- Spill and accident procedures.
- Decontamination procedures for personnel and equipment.
- Waste disposal procedures.

A CSP can be developed for a process, a chemical, or a class of chemicals (such as flammable liquids). The idea is to ensure that all procedures involving physical hazards or hazardous materials are covered by a CSP while generating the least amount of CSP's. With this in mind, it is important to note that multiple processes may be covered by one CSP if the safety information on the form is applicable to all processes listed on the form. For example, a lab may have many different processes for organic distillation that differ slightly in how they are performed, but the safety information for each process is the same or only differs slightly. In this case, one CSP may be used for all organic distillation processes with any slight variations noted on the form.

The Chemical Hygiene Officer keeps a record of all completed CSP's. Prior to completing CSP's for a laboratory, the faculty member should consult with the Chemical Hygiene Officer to review the completed departmental CSP's and obtain copies of any that may be applicable to her/his laboratory. If a CSP needs to be developed for a specific lab process (because no existing CSP covers the process adequately), it is recommended to have the student or lab worker responsible for the process to develop the CSP and have it reviewed by the supervising faculty member prior to submittal to the Chemical Hygiene Officer.

Laboratory Requirements

- Develop Chemical Safety Protocols (CSP's) to address all procedures involving physical hazards or hazardous materials using the CSP form in this Chemical Hygiene Plan (Appendix B). Consult with the Chemical Hygiene Officer prior to developing CSP's to obtain copies of CSP's already completed that may be applicable.
- Utilize students or lab workers responsible for the process to develop the CSP's whenever possible.
- Provide and train laboratory staff on the applicable CSP's prior to allowing them to conduct research.
- Submit copies of completed CSP's to the Chemical Hygiene Officer.

4.4 LABORATORY-SPECIFIC SAFETY PLANS

While this Chemical Hygiene Plan addresses safety rules and policies applicable to all Chemistry laboratories, each laboratory should develop a laboratory-specific safety plan to address safety rules and procedures that are unique to the lab and not addressed by this Chemical Hygiene Plan. Laboratory-specific emergency response procedures, if applicable, should also be developed. Chemistry Department is initiating a pilot project to formulate Laboratory-specific safety plans using Professor Gary Sulikowski's lab as a model. When this project is completed and evaluated, these lab-specific safety plans will be extended to the remaining labs in the chemistry department.

The lab-specific safety plan should include:

- Chemical Safety Protocols for all lab-specific processes involving physical/chemical hazards or hazardous materials. (See the "Chemical Safety Protocols" section of this Chemical Hygiene Plan for more information.)
- Written procedures for all lab processes involving physical hazards or hazardous materials. It is recommended to keep all written procedures covered by a Chemical Safety Protocol filed with that Chemical Safety Protocol.
- Laboratory-specific safety procedures, if applicable.
- Laboratory-specific emergency response procedures, if applicable.

4.5 LABORATORY SAFETY AUDITS

The Chemistry Safety Committee Student Tier will perform a safety and environmental compliance audit of all Chemistry research laboratories twice per year – once during the fall semester and once during the spring semester. The Chemistry Safety Committee Administrative Tier will arrange for appropriate training of the Student Tier on conducting these audits.

Audit Process

The students will work in teams of at least two members and will each be assigned a certain set of laboratories to audit by the Chemical Hygiene Officer. No student will audit a laboratory that they work in on a regular basis. The checklists to be used during the audits are provided in Appendix C. Each checklist item is categorized as "High Priority" or "Medium Priority." "Medium Priority" violations are safety or compliance issues that do not represent an immediate hazard to health and safety, the environment, or property. "High Priority" violations are safety or compliance issues that do represent an immediate hazard to health and safety, the environment, or property. The students will audit the labs and fill out the checklists including interviewing laboratory personnel where applicable. Each audit team will be issued a digital camera and will document safety or environmental issues observed by taking a digital photograph, if applicable. Notes will be taken for each photograph documenting where and when the picture was taken and the issue that is being shown.

Reporting Results

Each audit team will submit their completed audit checklists to the Chemical Hygiene Officer. Also, the digital photographs will be submitted to the Chemical Hygiene Officer along with the notes. The Student Tier will prepare a summary report of the audit findings that details how each laboratory performed and submit the report to the Chemistry Safety Committee Administrative Tier.

Corrective Actions

The Administrative Tier will review and finalize the audit results after resolving any questions or issues with Student Tier. This review process will check for accuracy and consistency of the audits. The Administrative Tier will then issue the results of the audit to each faculty member along with a letter detailing the required corrective actions, if applicable.

The corrective actions will be categorized by the Administrative Tier into three categories: High priority, Medium priority and Low priority. For Low priority corrective actions, the faculty member will receive a letter detailing the deficiencies observed. Any corrective action required is expected to be completed promptly by the concerned faculty members. If the same violations are found in two consecutive audits, the Administrative Tier will seek written response from the concerned faculty member about the corrective actions taken and protocols established in his/her lab to prevent repeat violations.

For Medium and High priority violations, the Administrative Tier will seek written response from the concerned faculty member about the corrective actions taken and protocols established in his/her lab to prevent future occurrence of same/similar violations. If the corrective actions are not completed within the specified time, then the concerned faculty member will be asked to report the status of corrective actions to the Chair of Chemistry. If the issues are not resolved at this stage, the Chair of Chemistry at his/her discretion may refer the issue to the Dean of College of Arts and Sciences for further actions.

4.6 CHEMICAL HYGIENE PLAN REVIEW

The Chemical Safety Committee Administrative Tier will review and/or amend the Chemical Hygiene Plan under the following circumstances:

- At least annually.
- Any time policies or procedures are changed that may affect the Chemical Hygiene Plan.
- Any time the Chemical Hygiene Plan is shown to not adequately address a chemical safety issue relative to the Department.

5.0 LABORATORY SAFETY MANAGEMENT of LABORATORIES IN BUILDINGS 5 AND 7.

5.1 GENERAL LABORATORY VENTILATION

The laboratories in the Chemistry Department are designed to provide adequate ventilation to prevent the buildup of vapors and gases. All laboratories are provided with 100 percent fresh outside air with no recirculation. The laboratories are designed to ventilate at a rate of 10 to 12 room exchanges per hour. The ventilation systems for the laboratories are maintained by the Heating, Air Conditioning, and Refrigeration shop (often referred to as the 'HAR shop') in Plant Operations.

Laboratory Requirements

- Do not block supply or exhaust registers.
- Do not place equipment in the laboratory in such a way as to block airflow from the ventilation system.
- Report any ventilation problems to the Plant Operations HAR shop (343-9675) immediately.

5.2 CHEMICAL FUME HOODS

Chemical fume hoods in laboratories are used to prevent or minimize personnel exposure to hazardous, offensive, or flammable gases and vapors and to prevent these vapors from mixing with the general room air. Also, a hood (with the sash down) can act as a physical barrier between lab workers and chemical reactions.

Each laboratory is provided with an appropriate number of ventilation hoods for the expected research work to be conducted. All hoods are equipped with air flow indicators -- either a digital flow monitor that displays the face velocity in feet per minute (fpm) or an analog flow monitor that uses colored lights to indicate flow status -- and a low flow alarm. The hoods are designed to operate with a face velocity in the range of 80 fpm to 120 fpm, with 100 fpm being the ideal velocity. VEHS performs routine inspections of the fume hoods to ensure adequate face velocity and proper air flow patterns. VEHS will also inspect fume hoods upon request if it is suspected that a hood is not operating properly. The fume hoods for the laboratories are maintained by the HAR shop in Plant Operations.

Laboratory Requirements

- Perform all work that may result in the generation or release of hazardous or offensive gases or vapors in a chemical fume hood. As a rule of thumb, use a chemical fume hood or other exhaust device when working with any appreciable volatile substance with a threshold limit value (TLV) of less than 50 parts per million (ppm), carcinogens, reproductive toxins, and highly toxic chemicals. The TLV for the chemical can be obtained from the material safety data sheet.
- Ensure the hood is working properly by checking the air flow indicator prior to use. Digital flow indicators should show a reading between 80 and 120 feet per minute and analog indicators should display a green light.

- Minimize the number of items stored in the hood and ensure that at least 50% of the working surface is clear.
- Items stored in the hood should be placed at least 6 inches into the hood from the face, placed to the sides of the hood, and, if possible, elevated 2 to 3 inches above the surface using shelving to minimize disruption to the airflow.
- Keep the vertical sash height at 18 inches or less from the working surface while working in the hood to ensure optimum flow rate and to protect yourself from potential chemical splashes or explosions. Horizontal sashes should be set to the minimum opening required to perform work.
- Work at least 6 inches into the hood from the face to minimize the potential for fumes to escape.
- Keep laboratory doors and windows closed and limit movement in front of the hood during use to minimize disruption to the airflow.
- Keep the sash closed when fume hood is not being used.
- Contact VEHS if you are planning on using perchloric acid, carcinogens, reproductive toxins, and/or highly toxic chemicals (see definitions) in your fume hood to see if any special precautions must be taken.
- Notify the Chemical Hygiene Officer or department Chair if the fume hoods available are not sufficient for your research work.
- Contact Plant Operations (343-9675) if your fume hood is not working properly.

5.3 GLOVE BOXES AND OTHER LOCAL EXHAUST VENTILATION

Glove boxes and other enclosed or special exhaust ventilation systems are used to prevent personnel exposure to hazardous, offensive, or flammable gases and vapors, to prevent these vapors from mixing with the general room air, and/or to provide a controlled atmosphere for the use and storage of certain chemicals.

Glove boxes are usually small units that have multiple openings in which arm-length rubber gloves are mounted. The operator works inside the box by using these gloves. Some glove boxes operate under negative pressure such that any leakage is into the box. If the material being used in the box is sufficiently toxic to require use of an isolation system, the exhaust air may require special treatment (scrubbing or adsorption) before release into the regular fume hood exhaust system.

All of the glove boxes used in the Chemistry Department at Vanderbilt University operate under positive pressure. These boxes are commonly used for experiments for which protection from atmospheric moisture or oxygen is desired. If positive-pressure glove boxes are used with highly toxic materials, they should be thoroughly tested for leaks before each use. Also, a method to monitor the integrity of the system (such as a shutoff valve or a pressure gauge designed into it) is required.

Laboratory Requirements

- Design, install, and maintain glove boxes in accordance with manufacturer's recommendations and applicable government and industry standards.

- Contact VEHS if you are planning on using carcinogens, reproductive toxins, and/or highly toxic chemicals (see definitions) in your glove box to see if any special precautions must be taken.

5.4 EMERGENCY RESPONSE EQUIPMENT

Emergency Showers

Emergency deluge showers are provided near all Chemistry laboratories in the corridors. The showers are maintained by the Plant Operations Plumbing shop in accordance with applicable standards. Contact the Chemical Hygiene Officer and/or the Plumbing Shop (322-2622) for problems with the emergency showers. Pathways to and access to the emergency showers should never be blocked or obstructed.

Eyewash Stations

Eyewash stations are provided in or near all Chemistry laboratories. The eyewash stations are maintained by the Plant Operations Plumbing shop (322-2622) in accordance with applicable standards. Contact the Chemical Hygiene Officer and/or the Plumbing Shop for problems with the eyewash stations. Pathways to and access to the eyewash stations should never be blocked or obstructed.

Fire Extinguishers

Each laboratory is equipped with fire extinguishers of the ABC type which are designed to work for ordinary combustibles (wood, cloth, paper, etc.), liquids, greases, gases, and energized electrical equipment. These extinguishers are not appropriate for fires involving metals such as magnesium, sodium, or potassium. Laboratories that work with these metals should maintain Class D fire extinguishers or buckets of sand to use as an extinguishing agent. The fire extinguishers provided by Vanderbilt University are maintained by the Plant Operations Plumbing Shop (322-2622). Pathways to and access to the fire extinguishers should never be blocked or obstructed.

Chemical Spill Response Kits

Chemical spill response kits are maintained in all Chemistry Department laboratories. The kits consist of absorbent pads and granular material that can be used on any solvents or corrosive liquids except for hydrofluoric acid. Contact the Chemical Hygiene Officer for assistance with obtaining a spill kit or replenishing a spill kit after it has been used. Pathways to and access to the chemical spill response kits should never be blocked or obstructed.

First Aid Kits

Each laboratory is provided with at least one first aid kit. The first aid kit contains bandages and disinfectant wipes to treat minor cuts, scrapes, abrasions, and burns.

Contact the Chemical Hygiene Officer to obtain or replenish a first aid kit. Pathways to and access to first aid kits should never be blocked or obstructed.

Laboratory Requirements

- Never block pathways or access to emergency showers, eyewash stations, fire extinguishers, chemical response kits, or first aid kits.
- Contact the Plant Operations Plumbing shop for problems with the emergency showers, eyewash stations, or fire extinguishers (322-2622).
- Contact the Chemical Hygiene Officer to obtain or replenish a first aid kit or spill response kit.

5.5 LABORATORY ATTIRE

The laboratory attire restrictions described below apply to lab personnel (including students) that are either performing work with hazardous materials or are spending an appreciable amount of time in the lab, including the desk areas in the lab.

Clothing and Hair

Clothing worn while working in the laboratory should offer protection from splashes and spills, should be easily removable in case of an accident, and should be at least fire resistant. It is advisable to avoid wearing flammable polymeric fabrics that melt while burning and adhere to the skin.

Clothing should cover the legs. Shorts, cutoffs, and miniskirts are not recommended. Loose or flowing apparel should not be worn in the laboratories in order to reduce the risk of coming in contact with hazardous chemicals or mechanical equipment and to prevent contamination of the work environment. Long hair should be secured while working in the lab to avoid unintended contact with chemicals or flames or catching in equipment.

Footwear

High-heeled, open-heeled, and/or open-toed shoes, sandals, and shoes made of woven or porous material are not recommended while working in the laboratory.

Jewelry

Jewelry such as rings, and watches are not recommended to be worn during lab work, to prevent chemical seepage under jewelry, contact with electrical sources, catching on equipment. These items are recommended to be stored in individual desks while carrying out the lab work.

Laboratory Requirements

- Wear clothing that covers the legs and that is easily removable in the event of an accident.
- Avoid wearing loose or flowing clothing and clothing made of flammable polymeric fabrics.
- Wear shoes without high heels that are closed-toed, closed-heeled, and not made of woven or porous fabrics.
- Secure long hair.
- Jewelry such as bracelets and watches are recommended to be stored in individual desks during lab work

5.6 PERSONAL PROTECTIVE EQUIPMENT

Eye and Face Protection

Eye and face protection are required by regulatory standards anytime there is a potential exposure to flying particles, molten metal, liquid chemicals, acids or caustic liquids, chemical gases or vapors, or potentially hazardous light radiation (welding flash, burning flame, UV lights, lasers). Eye and face protection for a particular lab process should be selected based on the potential for exposure or damage to the eyes and face.

Protective eyewear must be worn any time there is a possibility of foreign objects entering the eyes, including liquid splashes and particulate matter. These safety glasses must conform to American National Standards Institute (ANSI) Standard Z87.1. At a minimum, visitors in Chemistry laboratories will be required to wear safety glasses at all times while in the lab.

Safety goggles without ventilation or with indirect ventilation may be required for operations where the possibility of liquids contacting the eyes exists. Note that direct ventilation goggles that do not protect liquids from entering the vents should not be worn to protect against chemical splashes. Also, note that goggles without any ventilation tend to fog up and become difficult to see through. All goggles used must conform to ANSI Standard Z87.1.

If damage to the eye AND face could occur, face shields may be required in addition to goggles or safety glasses. For instance, a mild corrosive might present an eye hazard, but a concentrated one could cause massive facial burns, requiring eye AND face protection. Face shields must never be worn alone. Face shields must always be worn over either safety glasses (for impact hazards only) or safety goggles (for splash hazards). All face shields used must conform to ANSI Standard Z87.1.

Certain chemicals for which the Occupational Safety and Health Administration (OSHA) has developed regulations (see Regulated Chemicals section), have specific regulatory requirements for eye protection based on exposure levels. These regulatory requirements take precedence over written standard operating procedures when there is a conflict between the two. For example, performing experiments with exposure to formaldehyde above the OSHA Permissible Exposure Limit (see definitions) requires the use of a full-

face respirator or a half-mask respirator with gas-tight goggles. If work is to be performed with these chemicals, consult with the Chemical Hygiene Officer to determine if any special regulations apply.

Special eye protection is available for working with lasers, ultraviolet light, welding and brazing or intense light sources. Consult with the Chemical Hygiene Officer for selecting appropriate eye protection for operations involving these eye hazards.

As stated in the Personal Hygiene section, safety goggles should be worn by lab workers wearing contact lenses.

Laboratory Coats

Laboratory coats are recommended while working in the laboratory. Lab coats are recommended to be buttoned while working in the labs. Lab coats should be removed immediately if they become contaminated and washed before reusing. Periodically wash lab coats even if no known contamination has occurred. Do not take laboratory coat home to wash. Chemistry is evaluating the in-house access to a laundry service that will launder laboratory coats. Never wear lab coats into areas where food is consumed, stored, or prepared.

Laboratory Aprons

Working with highly caustic, corrosive or highly toxic chemicals that can be absorbed through the skin may require the use of a laboratory apron. Laboratory aprons must be constructed of a material that is chemically resistant to the specific chemical(s) being used and must be non-flammable. Consult the material safety data sheet (MSDS) for the substance being used for recommendations on material types.

Gloves

Chemically protective gloves are designed to protect workers' hands and sometimes forearms from exposure to chemicals which may physically injure the skin or be absorbed through the skin and affect other areas of the body.

Disposable nitrile gloves should be worn for general lab operations. To select the proper glove material for a particular process, review the material safety data sheet (MSDS) for the substance being used. The MSDS will usually list one or more glove materials that are recommended. Chemical glove manufacturers also publish permeation tables or compatibility charts for common chemicals with projected breakthrough times. Breakthrough times express the length of time required for the chemical to be detected on the inside of the glove after exposure to the chemical on the outside of the glove. Higher breakthrough times represent a higher degree of protection for the employee. Remember that gloves are an expendable item and should be discarded and replaced within safe permeation times listed on the manufacturer's tables. The VEHS website (www.safety.vanderbilt.edu) has links to glove guides provided by glove manufacturers.

Common latex gloves offer little or no protection against most hazardous chemicals and are not recommended.

Glove types range from wrist length, to forearm length, to shoulder length and also range from disposable to varying degrees of thickness. To select the proper glove type for a particular process, evaluate the task and possible splash, immersion and contact hazards. Processes that are known to involve hand contact with or submersion in hazardous liquids or that have a reasonable risk of significant contact with or submersion in hazardous liquids require the use of non-disposable gloves.

All safety gloves should be inspected prior to each use. Lab workers should look for holes, excessive wear, and tears prior to donning gloves. After each use of non-disposable gloves, the exterior of the gloves should be rinsed thoroughly before removing the gloves – if the gloves are observed to be compromised or damaged, they should be discarded. Disposable gloves are not recommended to be reused. Non-disposable gloves should be discarded periodically. How often the gloves should be discarded will depend on the glove type, use in the laboratory, construction material, permeation times for chemicals handled, and inspection of the gloves.

Respirators

Respiratory protection is typically provided by engineering controls in the form of chemical fume hoods and other local exhaust devices. Laboratory personnel should protect themselves from inhalation hazards by using product substitution, engineering controls, or process modifications whenever possible. The use of respirators for protection against inhalation hazards should be the last option.

Respirator use requires a written respiratory protection program, medical surveillance, and fit-testing. Wearing a respirator requires prior approval from VEHS. If it is suspected that respirators will be needed, consult with the Chemical Hygiene Officer about obtaining approval from VEHS.

Laboratory Requirements

- Select personal protective equipment (PPE) for a process based on an evaluation of the potential exposure hazards. The PPE required for a process should be specified in the Chemical Safety Protocol.
- Always wear the specified PPE for a process.
- Use safety glasses for eye protection against projectiles.
- Use safety goggles for eye protection against chemical splashes or fine particulate matter.
- Use face shields in addition to safety goggles for protection of the face against chemical splashes.
- If contact lenses are worn in the laboratory, safety goggles should also be worn.

- Ensure that all lab visitors have at least safety glasses on at all times while in the lab.
- Lab coats are recommended for body protection while working in the lab.
- It is recommended that lab coats be buttoned while working in chemical labs.
- Contaminated lab coats are recommended to be given for professional cleaning.
- Chemistry department is evaluating the in-house professional laundry service for lab coats.
- Use chemically resistant, non-flammable laboratory aprons for processes that involve a reasonable risk of splashing caustic, corrosive or highly toxic chemicals that can be absorbed through the skin onto the body.
- Use disposable nitrile gloves for general lab operations.
- Latex gloves are not recommended for use with chemicals.
- Select the proper glove material (nitrile, butyl rubber, neoprene, viton, etc.) for a particular chemical by consulting the MSDS for the chemical or a glove compatibility chart provided by the manufacturer. Specify the appropriate glove material in the Chemical Safety Protocol.
- Select the proper glove type (thickness, length, etc,) for a particular process by evaluating the task and possible splash, immersion and contact hazards. Specify the appropriate glove type in the Chemical Safety Protocol.
- Remember that gloves are an expendable item and should be discarded and replaced within safe permeation times listed on the manufacturer's tables.
- Inspect gloves prior to use.
- Disposable gloves are not recommended for reuse.
- Thoroughly rinse non-disposable gloves prior to removal.
- Dispose of non-disposable gloves periodically.
- Wash hands after removing gloves.
- Never wear a respirator without prior approval from VEHS.

5.7 PERSONAL HYGIENE

Personal hygiene procedures are designed to protect laboratory workers from ingesting or otherwise being adversely exposed to hazardous chemicals, biological materials, or radioactive materials. The following personal hygiene procedures apply to all laboratory areas including the desk areas in the laboratories. Break areas, offices, or other areas where these procedures do not apply must be separated from lab areas by floor to ceiling walls or have been designated as acceptable by the Chemical Hygiene Officer.

Laboratory Requirements

- Do not prepare, store (even temporarily), or consume food or beverages in the laboratory. This includes storage areas and refrigerators.
- Do not smoke, consume or store tobacco products in the laboratory. Additionally, be aware that tobacco products in open packages can absorb chemical vapors.

- Chewing gum or applying cosmetics are not recommended in chemical laboratories.
- No evidence of food or tobacco consumption should be present in the laboratory. This means that laboratory desks, benches, trash cans, etc. should not have any wrappers or other empty food containers that indicate that these items might have been consumed in the lab.
- Do not store or use food preparation and storage equipment (such as microwaves, refrigerators, and coffee makers) in the laboratory.
- Refrigerators used for chemical storage should be conspicuously labeled on the outside with the words, "Chemical Storage Only."
- Glassware or utensils used for laboratory operations should never be used to contain or prepare food or beverages.
- Wash hands and arms thoroughly before leaving the laboratory, even if gloves and a lab coat have been worn.
- If contact lenses are worn in the laboratory, safety goggles should also be worn.
- Do not take laboratory coat home to wash. The Vanderbilt Department of Chemistry will provide access to a laundry service that will launder laboratory coats.
- Never wear or bring lab coats or aprons into areas where food is consumed, prepared, or stored.
- Never pipette by mouth. Always use a pipette aid or suction bulb.
- Never wear gloves into non-laboratory areas including elevators.
- Confine long hair and loose clothing while working in the laboratory.

5.8 HOUSEKEEPING

Laboratory Requirements

- Keep aisle ways, exits, halls, stairways, and access to emergency equipment or controls free from clutter or obstructions. Lack of storage space is not an excuse for blocking aisle ways. Contact your supervisor or the Chemical Hygiene Officer if more storage space is needed.
- Keep lab benches, hoods, tables, etc. clean and uncluttered.
- After an experiment or class is completed, clean workspaces (including bench tops and floors), dispose of waste properly, and return chemicals and equipment to their proper storage locations.
- Dispose of glass in an appropriate broken glass container and never in a regular trash can.
- Clean up spills immediately in accordance with the chemical response procedures for the laboratory.
- Keep floors and walkways dry and free from slip/trip/fall hazards at all times.
- Place electric cords, tubing, cables, etc. above walk spaces and thresholds.
- Work areas should be inspected at the beginning and end of each day to ensure proper housekeeping.

5.9 WORKING IN THE LABORATORY

Laboratory Requirements

- Never work alone in the laboratory without making provisions. Individuals working alone in separate laboratories should make arrangements to check on each other periodically. For hazardous processes, ensure that someone else is aware of what you are doing and is in constant contact with you. For non-hazardous processes, the presence of someone else in the vicinity is adequate.
- Undergraduate students should never work alone and should always be supervised by their faculty member or a designated representative while working in a laboratory. Undergraduate students must meet the requirements of and sign a "Safety Training and Awareness Certification" form prior to performing research work in a lab.
- Do not engage in horseplay or practical jokes and avoid distracting or startling other workers in the laboratory.
- Use laboratory equipment only for its designated purpose.
- Do not allow children or pets in laboratories where hazardous materials are stored or used.
- Make sure that all visitors to the laboratory are in proper attire and necessary personal protective equipment. Safety glasses are the minimum personal protective equipment required for visitors in all chemical laboratories.
- Make sure you are familiar with the chemicals you are working including their hazardous properties and signs and symptoms of exposure.
- Ensure proper exhaust ventilation is present for work with chemicals.
- Handle and store laboratory glassware with care to avoid damage. Damaged glassware should be disposed of immediately.
- Use extra care with Dewar flasks and other evacuated glass apparatus. Shield or wrap them to contain the chemicals and glass fragments should implosion occur.
- Ensure that written procedures including a Chemical Safety Protocol exists and have been reviewed and approved for any new procedure.
- Only well understood processes will be allowed to run unattended. When unattended operations are required, leave the lights on, place a sign on the door, and provide containment for any hazardous substances in the event of failure of the system.
- Never smell or taste a chemical.
- Apparatus that may discharge or release hazardous vapors, gases, or dust (vacuum pumps, distillation columns, etc.) must be vented into an appropriate local exhaust device.
- Store items that weigh more than 10 pounds or that are awkward to lift due to their size or shape on shelves at chest level or below.

5.10 LABORATORY SECURITY

Laboratory Requirements

- Keep lab doors locked anytime no one is present in the lab. This includes after hours. Do not rely on building security to restrict access to the labs. Access must be restricted at the lab door.
- Question strangers in the lab.
- Require lab staff to have identification or proper credentials with them at all times while in the lab.
- If necessary, lock cabinets, refrigerators, or freezers where hazardous materials are stored for additional security.
- Restrict/control access to the lab by limiting the number of people with keys and combinations.

5.11 LABORATORY RECORDKEEPING

The following documents should be maintained in the laboratory and available for review by an auditor:

- Copy of this Chemical Hygiene Plan.
- Laboratory-Specific Safety Plan including written procedures and Chemical Safety Protocols for all lab processes involving physical hazards or hazardous materials.
- Training documentation for annual lab-specific safety training. The most recent training documentation is all that is required to be maintained.
- Material safety data sheets (MSDS's) for all chemicals used or stored in the lab. These must be maintained in the lab where the chemicals are used either in paper form in a binder or in electronic form on a disk or local hard drive.
- A chemical inventory for all hazardous chemicals (including gases) used or stored in the lab. The inventory should include the chemical name, physical state, quantity, and general location at a minimum.
- The "Laboratory Guide for Managing Chemical Waste."
- A copy of the "Faculty/Student Agreement" for any undergraduate students performing research work in the lab.

5.12 WORK REQUIRING PRIOR APPROVAL

Certain activities need approval from the Chemical Hygiene Officer/VEHS prior to implementation in the lab. The Chemical Hygiene Officer/VEHS will ensure that all appropriate safety measures have been taken and that the work is being conducted in accordance with applicable regulations and policies. Work that requires prior approval by the Chemical Hygiene Officer/VEHS includes the following:

- Work with substances described in the "Working With Particularly Hazardous Substances" section of this Chemical Hygiene Plan.

- Work with animals.
- Work with hazardous biological materials, recombinant DNA, or human or primate biological materials (body fluids, tissues, cells, etc.).
- Work with radioactive materials.
- Installation of a laser.

Laboratory Requirements

- Working with particularly hazardous substances (as defined by this Chemical Hygiene Plan), animals, hazardous biological materials, recombinant DNA, human or primate biological materials, radioactive materials, and lasers requires approval from the Chemical Hygiene Officer/VEHS.

5.13 BIOLOGICAL MATERIALS AND ANIMALS

This Chemical Hygiene Plan does not address the use of biological materials or animals in laboratories. Additional requirements apply to the use of these materials. Contact VEHS (322-2057) for more information.

5.14 RADIOACTIVE MATERIALS

This Chemical Hygiene Plan does not address the use of radioactive materials and equipment in laboratories. Additional requirements apply to the use of these materials. Contact VEHS (322-2057) for more information.

6.0 LABORATORY CHEMICAL MANAGEMENT

6.1 CHEMICAL PROCUREMENT AND DISTRIBUTION

The Chemistry Department has a central stockroom on the third floor of the Chemistry Building (Stevenson Center Building 7). All chemicals ordered by personnel in the Chemistry department are received and temporarily stored in the Chemistry stockroom. Additionally, the stockroom maintains a supply of commonly used chemicals for distribution to the laboratories. The stockroom also receives and temporarily stores some compressed gas cylinders prior to distribution to the laboratories.

Prior to distribution to the labs, chemicals stored in the stockroom must be stored in the appropriate location and segregated according to the hazard class of the chemical. Storage areas are not to be used for chemical preparation or repackaging.

Laboratory Requirements

- Inspect all chemical containers and gas cylinders prior for leaks or defects prior to removing them from the Chemistry stockroom.
- Transport chemical from the Chemistry stockroom to the laboratory in a safe manner utilizing secondary containment for liquid chemicals.

- Transport compressed gas cylinders with valve covers securely fastened using an appropriate gas cart and strap or chain the cylinder to the cart securely.
- Wear appropriate personal protective equipment when transporting chemicals and cylinders.

6.2 CHEMICAL HAZARD INFORMATION

Faculty members must ensure that lab workers have access to hazard information for all hazardous chemicals they work with in the laboratories. This information must include at a minimum:

- The contents of the TOSHA Laboratory Standard and its appendices which must be made available. (A link to this information is provided on the Department website.)
- The location and availability of this Chemical Hygiene Plan and the Laboratory-Specific Safety Plan.
- Permissible exposure limits (PEL's) for TOSHA regulated substances or recommended exposure limits for other hazardous chemicals where there is no applicable TOSHA standard. (Available on material safety data sheets)
- Signs and symptoms associated with exposures to hazardous chemicals used and stored in the laboratory. (Available on material safety data sheets)
- The location and availability of ACS booklet on Safety, Laboratory Techniques books that describe safety procedures and known reference material on the hazards, safe handling, storage and disposal of hazardous chemicals found in the laboratory, including but not limited to material safety data sheets received from the chemical supplier.

Material Safety Data Sheets

Material Safety Data Sheets (MSDS's) must be maintained for all hazardous chemicals used or stored in the laboratory. The MSDS's must be located in the lab where the chemicals are used or stored and not kept in a central Department office. Lab staff must be trained on and know the location of the MSDS's. Having access to MSDS's through the internet or server is not considered an acceptable method of providing access to MSDS's. Acceptable means of maintaining MSDS's in the lab include:

- Keeping paper copies in a binder located in the lab.
- Keeping an electronic copy on a local hard drive.
- Keeping an electronic copy on a disk.

MSDS's can be obtained from a variety of sources including the website of the manufacturer of the chemical or on one of the searchable internet MSDS repository services. VEHS has subscribed to several of these services which can be accessed at this location through the internet: http://www.safety.vanderbilt.edu/msds/index.htm. Contact VEHS (322-0257) if there is any difficulty in obtaining an MSDS.

Container Labels

Incoming chemicals must not have their labels removed or defaced. If chemicals are transferred to another container, that container should be labeled with the common chemical name. Formulas, abbreviations, and/or symbols should not be used as the sole means to identify the chemical. Also, for glass containers, it is preferable to create a label for the chemical as opposed to writing on the glass with markers so that the chemical label will remain intact if the bottle breaks. For chemicals created in the lab that do not have a name, appropriate reference should be made to information regarding the potential hazards of the chemical.

Lab Hazard Signs

The Vanderbilt Environmental Health and Safety Department (VEHS) posts Lab Hazard Signs on entrance ways to all laboratories using hazardous materials. Every entrance to the lab that may be used by an emergency responder must be posted with a Lab Hazard Sign. The signs are designed to provide emergency responders with information regarding the chemical, biological, and radiological hazards in the lab as well as emergency names and numbers for people responsible for the lab. The faculty members must ensure that Lab Hazard Signs are posted properly on their labs and notify VEHS immediately under the following circumstances:

- A Lab Hazard Sign is not posted on all entrance ways to the lab.
- The emergency contact information needs to be changed on the sign.
- The sign needs to be amended to reflect changes in the hazardous materials used or stored in the lab.

Chemical Inventories

Chemistry department has started a pilot project on creating electronic chemical inventory using a commercial software. After the completion and evaluation of this pilot project, electronic inventory will be extended to all chemistry laboratories. Each lab will maintain an inventory of all hazardous chemicals used and stored in the lab. This inventory will be updated at least annually and kept in paper or electronic form. This inventory will include the following at a minimum:

- Chemical name.
- Physical state.
- Quantity.
- General location.

The Chemistry Department has a site license for an electronic chemical inventory program that is available to all Chemistry Department faculty members. Also, VEHS subscribes to a web-based, chemical inventory program that is available to all Vanderbilt

chemical users. Contact the Chemistry Department Chair and/or VEHS (322-2057) for information on these resources.

Chemicals synthesized in the Laboratory

For chemicals synthesized in the laboratory for the exclusive use of the laboratory, if the chemical substance is known, the faculty member must determine if it is a hazardous chemical based on available data. If the chemical is determined to be hazardous, the faculty member must provide information on the hazards of the chemical and appropriate training to required personnel (including students) in accordance with this Chemical Hygiene Plan. When the data are insufficient to determine if a chemical is hazardous, the faculty member must assume it is hazardous and must provide information on the potential hazards of the chemical and appropriate training to required personnel (including students) in accordance with this Chemical Hygiene Plan.

If the chemical substance is produced for another use outside of the laboratory, the faculty member must comply with the OSHA/TOSHA Hazard Communication Standard including the requirements for preparation of material safety data sheets and labeling.

Laboratory Requirements

- Faculty members must ensure that lab workers have access to information about the hazardous materials used and stored in the lab.
- Material safety data sheets (MSDS's) for all chemicals used or stored in the lab must be maintained in the lab. These must be either in paper form in a binder or in electronic form on a disk or local hard drive.
- Lab workers need to know the contents of the TOSHA Laboratory Standard and its appendices which are available on the Department website.
- Incoming chemicals must not have their labels removed or defaced.
- Chemical containers must be labeled with the common name of the chemical. Abbreviations, formulas, and/or symbols should not be used as the sole means to identify a chemical.
- Inventories of hazardous chemicals used and stored in the lab must be maintained including the chemical name, physical state, quantity, and general location.
- Chemicals synthesized in the lab must be evaluated to determine if they are hazardous based on available data. If they are hazardous or a hazardous determination cannot be made, they must be addressed in accordance with this Chemical Hygiene Plan.
- Chemicals developed in the lab for use outside of the lab must comply with the OSHA/TOSHA Hazard Communication Standard including the requirements for preparation of material safety data sheets and labeling.

6.3 CHEMICAL STORAGE IN LABORATORIES

Each laboratory will be provided with adequate storage space for chemicals and supplies. The storage space will be specifically constructed for the type of chemicals stored in the space. If special storage is required, contact the Chemical Hygiene Officer for assistance. Any special requirements for storage should be discussed with the Chair of Chemistry Department.

The quantities of chemicals stored in the laboratory should be kept to a minimum. Hazardous chemicals which are infrequently used should be returned to the Chemistry Stockroom for storage or redistribution or to VEHS.

Hazardous chemicals must be stored properly in the laboratories. Chemicals in storage must be segregated by hazard class (flammable, corrosive, oxidizer, etc.) such that there is no reasonable potential for incompatible chemicals or chemical vapors to mix. To provide a guide, a table of chemicals and their incompatibilities is provided in Appendix A.13.

Peroxide Forming Chemicals

Some chemicals may explode with peroxide formation. These include: divinylether, divinyl acetylene, isopropyl ether, vinylidene, potassium metal, potassium amide, sodium amide (sodamide). These chemicals are not recommended to be stored beyond three months.

Upon concentration (distillation or evaporation) certain chemicals pose peroxide hazard. These include: acetal, cumene, cyclohexene, cyclopentene, diacetylene, dicyclopentadiene, diethylene glycol dimethyl ether (diglyme), diethylether, dioxane (p-dioxane), ethylene glycol dimethyl ether (glyme), furan, methyl acetylene, methyl cyclopentane, methyl-t-butyl ketone, tetrahydrofuran, tetrahydronaphthalene, vinyl ethers. These chemicals are not recommended to be stored beyond 12 months.

Some chemicals polymerize violently due to peroxide initiation. These include: acrylic acid, acrylonitrile, butadiene, chlorobutadiene, methyl methacrylate, styrene, tetrafluoroethylene, vinyl acetate, vinyl acetylene, vinyl chloride, vinyl pyridine, vinylidene chloride. These chemicals are not recommended to be stored beyond 12 months.

Since some of these chemicals are packaged in an air atmosphere, peroxides can form even in unopened containers. Therefore, it is very important to write the date received and date opened on all containers of these chemicals. These chemicals should be stored in the smallest container possible, away from heat and sunlight and any source of ignition, and in a flammable storage cabinet or refrigerator/freezer certified for storing

flammable materials. Containers of these chemicals should have labels providing the following information: (a). Date Received, (b). Date Opened and (c). Date tested.

Laboratory Requirements

- Keep quantities of chemicals stored in the laboratory to a minimum.
- Store all chemicals in a clean, dry location away from sunlight, extreme temperature changes, and sources of ignition.
- Segregate chemicals by hazard class such that there is no reasonable potential for incompatible chemicals or chemical vapors to mix.
- Label all peroxide forming chemicals (ethers and tetrahydrofuran) with the date received and date opened. For these chemicals, dispose of opened containers within 6 months and unopened containers within one year.
- Store highly toxic, corrosive, and flammable chemicals below eye level. These chemicals should not be stored above the first shelf on the lab benches.
- Do not store chemicals that are not actively being used in fume hoods or on bench tops.
- Do not store liquid, hazardous chemicals near sink, floor, or hood drains unless secondary containment is provided to prevent spills from entering the drains.
- Store volatile toxics and odoriferous chemicals in a ventilated cabinet.
- Store all flammable liquids not actively being used in approved flammable materials storage rooms or cabinets and away from potential ignition sources.
- Flammable liquids in use that are stored outside of a flammable liquid cabinet (including wastes) must be kept to a minimum and must never exceed the lesser of 2 gallons per square foot of lab space or 150 gallons.
- Glass containers used to store flammable liquids must not exceed 4 liters.
- Total quantities of flammable liquids (including wastes) stored in the lab (including those stored in flammable cabinets) should be kept to a minimum and must never exceed 4 gallons per square foot of lab space or 300 gallons.
- Chemical storage areas such as refrigerators, cabinets, and drawers, should be labeled with signs that indicate the hazards of the chemicals stored within (i.e., flammable, corrosive, toxic, reproductive toxin, cancer-suspect agent, oxidizer).
- Ensure that all chemical containers are clearly labeled with the chemical name and appropriate hazard warnings. Chemical abbreviations, symbols, and structures should not be used as the sole means of communicating this information.
- Label glass containers with physical labels rather than writing on the glass so that the chemical can be identified if the bottle is broken.
- Never store chemicals at desks or in offices or other non-laboratory areas.
- Refrigerators used to store flammable liquids must be Underwriters-approved for flammable storage by the manufacturer – these refrigerators are designed not to spark inside.
- Do not store glass containers of chemical liquids on the floor.
- Chemicals or other hazardous materials should not be stored within 18 inches of the edge of bench tops.

6.4 WORKING WITH PARTICULARLY HAZARDOUS SUBSTANCES

Working With Allergens, and Embryotoxins and Reproductive toxins

Special precautions should be taken when working with allergens, embryotoxins and reproductive toxins. Examples of allergens are diazomethane, isocyanates, and bichromates. Examples of embryotoxins are organomercurials, lead compounds, and formamide. Anesthetic gases, arsenic and certain arsenic compounds, benzene, cadmium and certain cadmium compounds, carbon disulfide, ethylene glycol monomethyl and ethyl ethers, ethylene oxide, lead compounds, mercury compounds, toluene, vinyl chloride, xylene, and formamide are some examples of reproductive toxins. MSDSs and applicable toxicology textbooks should be consulted to determine if a particular chemical used in a specific process is an allergen, embryotoxin or reproductive toxin.

Individuals of childbearing potential need to be cautious when working with embryotoxins/reproductive toxins. The use of appropriate protective apparel (especially gloves) to prevent skin contact is important. Pregnant women and women intending to become pregnant should seek advice from knowledgeable sources such as VEHS.

Procedures for working with allergens:

- Wear chemically resistant gloves and laboratory apron to prevent skin contact.
- Wear face shield if potential exists for contact with the face.

Procedures for working with embryotoxins and reproductive toxins:

- Women of childbearing age should only handle these substances inside a hood after the proper performance of the hood has been verified.
- Wear chemically resistant gloves and laboratory apron to prevent skin contact.
- Review the procedures for the use of each embryotoxin/ reproductive toxins with VEHS or a physician. Procedures should be reviewed again whenever the procedure has been changed, and at least annually even if the procedure does not change.
- Embryotoxins/ reproductive toxins should be properly labeled and stored in an adequately ventilated area in an unbreakable secondary container.
- The laboratory faculty supervisor should be notified of all incidents of exposure or spills involving embryotoxins/ reproductive toxins. A physician should be consulted as necessary.

Working with Chemicals of Moderate Chronic or High Acute Toxicity

Examples of chemicals of moderate chronic or high acute toxicity are hydrofluoric acid, diisopropylfluorophosphate, and hydrogen cyanide. The following procedures should be used when working with chemicals of moderate chronic or high acute toxicity:

- Use and store these compounds only in areas of restricted access with special warning signs.
- Always use a hood or other containment device for procedures which may result in the generation of aerosols or vapors containing the substance. Hoods should have a face velocity of at least 60 linear feet per minute. Released vapors should be trapped to prevent their discharge with hood exhaust.
- Always avoid skin contact with these substances by wearing chemical resistant gloves and laboratory apron, long sleeves, and any other protective clothing deemed necessary after a review of the procedures.
- Always wash hands and arms thoroughly immediately after working with these compounds.
- Maintain accurate records of the amounts of these materials on hand, amounts used, and the names of the workers involved.
- At least two persons must be present when conducting procedures involving chemicals which are highly toxic or of unknown toxicity.
- Store breakable confiners of these substances in chemically resistant trays. Work and mount apparatus above chemically resistant trays, or cover work and storage surfaces with removable, absorbent, plastic backed paper.
- If a major spill occurs outside the hood, evacuate the area, and call VUPD at 911.
- Thoroughly decontaminate or incinerate contaminated clothing or shoes. If possible, chemically decontaminate by chemical conversion.
- Store contaminated waste in closed, suitably labeled, impervious containers.

Working With Chemicals of High Chronic Toxicity

Examples of chemicals with high chronic toxicity include dimethylmercury, nickel carbonyl, benzo-a-pyrene, and N-nitrosodiethylamine. When working with chemicals of high chronic toxicity, human carcinogens, or substances with high carcinogenic potency in animals, the following specific procedures should be used.

- Conduct all transfers and work with these substances in a controlled area. For purposes of this chemical hygiene plan, a controlled area is restricted access hood, glove box, or portion of a lab, designated for use of highly toxic substances, for which all people with access are aware of the substances being used and any necessary precautions.
- All work requiring the use of these substances requires an approved Chemical Safety Protocol.
- Protect vacuum pumps against contamination by using scrubbers or HEPA filters and vent them into a hood. Decontaminate vacuum pumps or other contaminated equipment, including glassware, inside the hood before removal from the controlled area.
- Decontaminate the controlled area before resuming normal work.
- Remove all protective apparel and thoroughly wash hands, forearms, face and neck before leaving a controlled area. Protective apparel should be placed in an appropriate waste receptacle.

- Dry sweeping of toxic substances which are dry powders is not allowed. Use a wet mop or a vacuum cleaner equipped with a HEPA filter instead.
- A physician (through the Occupational Health Clinic) should determine the desirability of regular medical surveillance when toxicologically significant quantities are used three times a week or more. The recommended medical surveillance policy should be posted in the CHP.
- Keep accurate records of the amounts of these chemicals which are stored or used in the laboratory, the dates of use, and the names of the users.
- The controlled area must be conspicuously marked with warning and restricted access signs. All containers of these substances must be appropriately labeled with identity and warning labels.
- A spill prevention, containment and control plan must be developed and posted in the controlled area. Materials needed to respond to a spill must be maintained in the area.
- Chemicals must be stored in a ventilated, limited access area in appropriately labeled, unbreakable, chemically resistant, secondary containers.
- Negative pressure glove boxes must have at least 2 volume changes per hour and at least 0.5 inches of water pressure. The exit gasses must be trapped or filtered through a HEPA filter and released into a hood.
- Wastes should be chemically decontaminated whenever possible. Containers of contaminated waste must be transferred from the controlled area in a secondary container under the supervision of VEHS.

Laboratory Requirements

- Working with particularly hazardous substances (allergens, embryotoxins, reproductive toxins, select carcinogens, substances with a high degree of acute toxicity or a moderate or high degree of chronic toxicity) requires special precautions, procedures, and training. Consult the Chemical Hygiene Plan and if necessary discuss with the Chemical Hygiene Officer/VEHS prior to conducting work with these materials.

6.5 EXPOSURE MONITORING

The Occupational Safety and Health Administration (OSHA) has established permissible exposure limits (PEL) to regulate personal exposures to specific chemicals. These regulatory limits were adopted by TOSHA. The control limits are contained in 29 CFR 1910 Subpart Z. Contact the Chemical Hygiene Officer/VEHS to review these PELs. Additionally, The American Conference of Governmental Industrial Hygienists (ACGIH) has published guidelines for exposure limits for specific chemicals. These guidelines are called threshold limit values (TLVs). The TLVs offer guidance on many chemicals not regulated by TOSHA.

The TOSHA Laboratory Standard requires that employers assure that employee exposures are kept below the PELs listed in 29 CFR Subpart Z. To determine and document employee exposures, employers are required to conduct air monitoring of employees' exposures whenever there is a reason to believe that exposure levels for a particular substance may routinely exceed the PELs. The air sampling will be performed by VEHS using approved sampling methodologies and an accredited laboratory.

The Chemical Hygiene Officer in consultation with VEHS will determine areas requiring routine exposure monitoring based on the amount of chemical used, protective measures in place and employee input on odors and health symptoms. Emergency exposure monitoring will be performed any time health complaints are received which can be attributed to exposure to hazardous chemicals. Currently, there is no exposure monitoring deemed to be necessary for known lab operations in the Chemistry Department.

All exposure monitoring records will be maintained by the Chemical Hygiene Officer. Employees will be notified of the results of their exposure monitoring within 15 working days after receipt of the sampling results. Employees and their representatives can have access to results from their personal monitoring by contacting the Chemical Hygiene Officer.

6.6 MEDICAL CONSULTATION AND EXAMINATIONS

All employees working with hazardous chemicals will be given the opportunity to receive medical attention at the Vanderbilt Occupational Health Clinic (OHC), Zerfoss Student Health Center, or at the Emergency Department at Vanderbilt University Medical Center (VUMC), if condition is immediately life threatening, including any follow-up examinations as needed. The following guidelines will be used:

- When an employee develops signs or symptoms associated with a hazardous chemical to which the employee may have been exposed in the laboratory, the employee will be given the opportunity to receive an appropriate medical examination. For non-life threatening exposures visit the Occupational Health Clinic (for employees of Vanderbilt) or Student Health Services (for students at Vanderbilt) during normal working hours. For emergencies or after hours incidents, visit the Vanderbilt Emergency Department at VUMC.
- When exposure monitoring reveals an exposure level routinely above the action level, or the Permissible Exposure Limit (PEL) if there is no action level, for a TOSHA regulated substance for which there are exposure monitoring and medical surveillance requirements (such as formaldehyde), medical surveillance will be established for the affected employee as prescribed by the applicable regulation.
- When an event takes place in the work area such as a spill, leak, explosion, or other occurrence resulting in the likelihood of exposure to a hazardous substance, the affected employee will be provided an opportunity for a medical consultation. The medical consultation will be used to determine the need for a medical examination.

All medical examinations and consultations will be performed by or under the direct supervision of a licensed physician and will be provided without cost to the employee, without loss of pay, and at a reasonable time and place.

The Chemical Hygiene Officer will provide to the health care provider:

- The identity of the hazardous chemical(s) to which the employee may have been exposed.
- A description of the conditions under which the exposure occurred including quantitative exposure data, if available.
- A description of the signs and symptoms of exposure that the employee is experiencing, if any.

The physician will provide a written opinion to the Chemical Hygiene Officer based on the medical consultation or examination. The written opinion will not contain specific findings of diagnoses unrelated to occupational exposure to hazardous chemicals. The written opinion will contain the following:

- Any recommendation for further follow-up;
- The results of the medical examination and any associated tests;
- Any medical condition which may be revealed in the course of the examination which may place the employee at increased risk as a result of exposure to a hazardous chemical in the laboratory;
- A statement that the employee has been informed by the physician of the results of the consultation or medical examination and any medical condition that may require further examination or treatment.

6.7 EMERGENCY RESPONSE PROCEDURES

Chemical Spills

Quick cleanup of chemical spills in the laboratory will help reduce airborne concentrations in the work area and reduce potential for dermal contact or contamination of experiments. This is especially true of chemicals with high vapor pressures. However, safety must always take precedence over the need to clean up after a chemical spill. Therefore, the following procedures will always be adhered to after a chemical spill has been detected:

- No faculty, staff, or student will ever attempt to clean up a chemical spill when the nature of the chemical is unknown. Whenever a spill is discovered where the chemical composition and airborne concentrations are unknown, the laboratory will be evacuated immediately, all entrances and exits to the laboratory will be closed, and call VUPD by dialing 911, who will notify VEHS. No employee may reenter the laboratory until the area has been cleared and released by VEHS.
- Each laboratory using hazardous chemicals must maintain appropriate clean up materials readily accessible to laboratory personnel. The “kits” should be specific

for the type of chemicals in use in the laboratory. Kits are provided by the Department in every Chemistry laboratory for responding to basic solvent and acid spills (not including hydrofluoric acid). The kits include absorbent pads, socks, and "Safety Sorbent" particulate material. Instructions for using the materials are included in the kits and should be reviewed by laboratory staff. Labs should supplement these spill kits with other kits or materials needed for response to specific chemicals in their labs that cannot be handled with these basic kits.

- Lab staff may only clean up "small" chemical spills (less than one liter) of known origin that they are comfortable in cleaning up and for which they have the proper spill clean up materials and personal protective equipment. "Small" chemical spills are those spills which can be contained with one absorbent pad or sock. In general, spills of chemicals that are volatile and toxic by inhalation should not be cleaned up by laboratory personnel. Anytime workers experience dizziness or nausea during a chemical clean up, the laboratory should be evacuated and VUPD should be notified.
- Used spill clean up materials must be disposed of as chemical waste through VEHS.

Chemical Exposures and Medical Emergencies

- Everyone that has a chemical exposure (even minor ones) to a hazardous chemical should seek medical attention to document the incident and ensure no health problems exist. For non-life threatening exposures visit the Occupational Health Clinic (for employees of Vanderbilt) or Student Health Services (for students at Vanderbilt) during normal working hours. For emergencies or after hours incidents, visit the Vanderbilt Emergency Department at VUMC.
- All chemical exposures (even minor ones) should be reported to the Chemical Hygiene Officer.
- Persons suffering from chemical exposure should be escorted to the appropriate medical facility and never sent alone. The material safety data sheet for the chemical involved should be taken if readily available.
- For ingestion of chemicals, refer to the chemical's material safety data sheet for immediate treatment procedures and seek medical attention promptly.
- For spills covering small amounts of skin, immediately flush with flowing water for no less than 15 minutes. If there is no visible burn, wash with warm, soapy water.
- For spills on clothes, do not attempt to wash or wipe the clothes. Quickly remove all contaminated clothing, personal protective equipment, jewelry, etc. and utilize the safety shower. It may be necessary to cut off some garments to prevent further contamination during removal. Immediately flush the affected area for at least 15 minutes. Resume if pain exists. Do not be concerned with flooding of the building or modesty. Seek medical attention as soon as possible.
- For splashes into the eye, immediately flush the eye in an eye wash station for at least 15 minutes. Hold the eyelids away from the eyeball and move the eye up

and down and sideways to wash thoroughly under the eyelids. Seek medical attention as soon as possible.

- Certain chemicals may require special immediate treatment other than a water rinse. Necessary treatment materials should be available for these chemicals and lab staff trained on their use. An example might be a chemical that needs to be rinsed with an alcohol rinse or the use of a calcium gluconate gel to treat an exposure to hydrofluoric acid.
- Bandage small cuts, burns, or abrasions with first aid kits.
- For non-chemical medical emergencies or illnesses, seek prompt medical attention. Minor injuries requiring first aid treatment may be treated by in house personnel trained in first aid procedures. Report all occupational injuries and illnesses to the Chemical Hygiene Officer as soon as possible after receiving medical treatment.
- For medical attention, visit the Vanderbilt Emergency Department for emergencies or after hours visits, and visit the Occupational Health Clinic (for employees of Vanderbilt) or Student Health Services (for students at Vanderbilt).

Fire and Fire Alarms

- Fires contained in small vessels can usually be suffocated by covering the vessel. Do not pick up the vessel. Remove nearby flammable materials to avoid spread of the fire.
- If the fire is burning over an area too large to suffocate the fire, all persons should evacuate except for those trained and qualified to fight the fire.
- Persons trained on using a fire extinguisher may attempt to fight small fires that they are confident they can extinguish.
- Fight fires from a position from which you can escape.
- To use a fire extinguisher, pull the pin, aim at the base of the fire, squeeze the handle, and sweep back and forth. Always start from 8 to 10 feet away and move in closer to avoid spreading the fire from the force of the extinguisher spray.
- If a fire is not out by the time one extinguisher has been discharged, give up and evacuate.
- The fire extinguishers provided in the labs are appropriate for all fires except those involving metals such as sodium or magnesium. Class D fire extinguishers should be used for metal fires.
- In the event a fire cannot be extinguished, evacuate the building in accordance with the Department Emergency Response Plan for the Chemistry Department (***link on Chemistry website to be added***). Rescue and remove other occupants only if you can do so without endangering yourself. Pull the fire alarm if necessary. Close doors and lower hood sashes if you can do so safely. Use stairs and stay low in smoky areas.
- If the fire alarm is sounding, all occupants must evacuate the building according to the Department Emergency Response Plan for the Chemistry Department. Assist and instruct visitors. Do not assume it is a false alarm.

Hood Failure

In the event of a hood failure (loss of adequate ventilation) where hazardous chemicals are being used or stored, move the materials to a nearby working hood, if feasible. Lower the sash to the hood and immediately report the problem to Plant Operations (343-9675) and the Chemical Hygiene Officer/VEHS.

Other Emergencies Requiring Building Evacuation

For other emergencies requiring building evacuation (bomb threats, explosions, etc.), follow the Department Emergency Response Plan for the Chemistry Department (***link on Chemistry website to be added***).

Laboratory Requirements

- Only clean up small chemical spills with no inhalation hazard for which you are comfortable with and have the appropriate clean up equipment and personal protective equipment.
- For spills that the lab personnel cannot clean up, evacuate and secure the area and notify VUPD immediately. Spill emergencies can be reported by dialing 911.
- Maintain spill kits in the lab suitable for spills that the lab intends to clean up and ensure that lab personnel are properly trained on their use.
- Dispose of used chemical spill clean up material as chemical waste through VEHS.
- Seek medical attention for all chemical exposures and when warranted by workplace injuries or illnesses.
- For non-life threatening chemical exposures, visit the Occupational Health Clinic (for employees of Vanderbilt) or Student Health Services (for students at Vanderbilt) during normal working hours. For emergencies or after hours incidents, visit the Vanderbilt Emergency Department at VUMC.
- Never send someone to a medical facility alone that is suffering from a chemical exposure. Always have them escorted and bring the appropriate material safety data sheet for the chemical involved.
- For chemical splashes into the eye, immediately flush the eye in an eye wash station for at least 15 minutes. Hold the eyelids away from the eyeball and move the eye up and down and sideways to wash thoroughly under the eyelids. Seek medical attention as soon as possible.
- For ingestion of chemicals, refer to the chemical's material safety data sheet for immediate treatment procedures and seek medical attention promptly.
- For chemical exposure to the body, remove contaminated clothing and flush with water in the emergency shower for at least 15 minutes.
- Only attempt to fight a fire if you are trained and qualified, have the appropriate fire extinguisher, and are confident that you will be successful.
- The fire extinguishers provided in the labs are appropriate for all fires except those involving metals such as sodium or magnesium. Class D fire extinguishers should be used for metal fires.

- To use a fire extinguisher, pull the pin, aim at the base of the fire, squeeze the handle, and sweep back and forth. Always start from 8 to 10 feet away and move in closer to avoid spreading the fire from the force of the extinguisher spray.
- In the event a fire cannot be extinguished, evacuate the building in accordance with the Department Emergency Response Plan for the Chemistry Department (***link on Chemistry website to be added***). Rescue and remove other occupants only if you can do so without endangering yourself. Pull the fire alarm if necessary. Close doors and lower hood sashes if you can do so safely. Use stairs and stay low in smoky areas.
- If the fire alarm is sounding, all occupants must evacuate the building according to the Department Emergency Response Plan for the Chemistry Department. Assist and instruct visitors. Do not assume it is a false alarm.

6.8 CHEMICAL WASTE DISPOSAL

All chemical wastes must be properly disposed of in accordance with the "Laboratory Guide for Managing Chemical Waste" provided by VEHS. Questions regarding chemical waste handling and disposal should be directed to VEHS (322-2057).

VEHS Chemical Waste Audits

VEHS audits all chemical waste storage areas at Vanderbilt once per year. Violations with proper procedures are documented and summarized in a report that is issued to the Chair of Chemistry, the Dean of Arts and Sciences, and the Chemistry Department Safety Committee. This report lists each faculty member that generates chemical waste and describes the compliance status of the faculty member's lab at the time of the audit. Questions regarding the VEHS chemical waste audit process should be directed to VEHS (322-2057; http://www.safety.vanderbilt.edu).

Laboratory Requirements

Training

- Every laboratory that generates chemical waste must have a hard copy of the "Laboratory Guide for Managing Chemical Waste" provided by VEHS.
- Every laboratory that generates chemical waste must have a "Hazardous Chemical Waste Management Area" sign (provided by VEHS) posted near their chemical waste storage location or in another conspicuous location in the lab.
- Laboratory staff that has to handle chemical waste must be trained in proper chemical waste management procedures.

Storage

- Every laboratory that generates chemical waste must have at least one area designated for chemical waste storage that is known by lab staff handling chemical waste.

- Store chemical waste in containers that are compatible with the chemicals and that are in good condition and free of leaks or chemical residue.
- Store all chemical waste containers that hold liquid chemical wastes in secondary containment so that spills cannot reach sink or floor drains or containers of incompatible chemicals. The secondary containment should be adequate to hold the entire contents of the largest container stored. Contact VEHS (322-2057) to obtain secondary containment equipment.
- Segregate chemical wastes by compatibility, and never store incompatible wastes in the same secondary containment.
- Store halogenated solvents in separate containers from non-halogenated solvents.
- Store chemical wastes in the same laboratory where they are generated such that the wastes do not have to be transported through offices, hallways, corridors or other public areas for storage.
- Never store more than 55 gallons of waste in one storage location.

Labeling

- Label chemical waste containers with waste tags provided by VEHS as soon as waste accumulation begins even if more waste will be added later. There should never be a chemical waste container in your lab that has waste in it and that is not labeled with a VEHS waste tag.

Closed Containers

- Keep chemical waste containers closed at all times except to temporarily add more waste. This means no open funnels are allowed unless you are actively pouring waste into the container.
- Chemical waste containers must be closed with a screw-type lid or a screw-on funnel equipped with a lid that snaps close and has a latch to prevent it from opening accidentally.

Spills

- Clean up chemical waste spills immediately. There should be no chemical waste residue on chemical waste containers or in secondary containment tubs.

Disposal

- Submit an online chemical waste collection request form to VEHS when your chemical waste is ready for pickup -- www.safety.vanderbilt.edu/resources/hazard_collection.htm.
- Never pour chemical wastes down sink or other drains unless it is approved by the "Laboratory Guide for Managing Chemical Wastes" or VEHS.
- Never evaporate chemicals in the fume hood as a method of disposal.

6.9 COMPRESSED GASES

Compressed gases expose the laboratory worker to both chemical and physical hazards. Safe storage, monitoring for leaks, and proper labeling are essential for the prudent use of compressed gases. If the gas is flammable, flash points lower than room temperature compounded by rapid diffusion throughout the laboratory present the danger of fire or explosion. Additional hazards can arise from the reactivity and/or toxicity of the gas, and asphyxiation can be caused by high concentrations of even inert gases such as nitrogen. Also, the large amount of potential energy resulting from the compression of the gas makes a highly compressed gas cylinder a potential rocket or fragmentation bomb.

Precautions are necessary for handling the various types of compressed gases, the cylinders that contain them, the regulators used to control their flow, the piping used to confine them during flow, and the vessels in which they are ultimately used. Regular inventories of cylinders and checks of their integrity with prompt removal of those that are no longer in use are important.

Hazardous Gases

Certain corrosive, highly toxic, flammable, and pyrophoric gases, such as silane, hydrogen fluoride, and phosgene, require special handling and storage procedures that may include storage in a gas cabinet or other ventilated storage device and continuous, automatic leak detection. Contact the Chemical Hygiene Officer for more information on requirements for specific hazardous gases.

Laboratory Requirements

Labeling & Storage

- Compressed gas cylinders should be labeled as to their contents. Note that the manufacturer label may not be adequate to describe the contents of the cylinder.
- Store cylinders so that their content labels are clearly visible.
- Store all cylinders in a dry, well ventilated area away from extreme temperature changes, sources of ignition or heat, moisture, and mechanical shock.
- Keep incompatible classes of gases stored separately. Keep flammables from reactives, which include oxidizers and corrosives. Gas cylinders of fuels (hydrogen, etc.) must be separated from gas cylinders of oxidizers (oxygen, etc.) by at least 20 feet or by a wall with a minimum fire rating of 2 hours.
- Always make sure that cylinders are secured to a permanent structural support and secured with a chain or a strap at two thirds of their height from the floor.
- For small cylinders or lecture bottles, utilize a stand or other appropriate mechanism to secure the cylinder to a stable surface.
- Segregate gas cylinder storage from the storage of other chemicals as much as possible.
- Cylinders ***that are in use*** must be secured individually so that no slippage or sliding occurs that could damage or alter the regulator.
- If cylinders must be ganged together for storage, only gang two cylinders together at a time, if possible.

- Cylinder carts are not a safe way of securing uncapped gases, even "only for a short time."
- Segregate empty cylinders from full cylinders and clearly mark the empty cylinders.

Usage

- Only Compressed Gas Association (CGA) standard combination of valves and fittings can be used in compressed gas installations.
- Gas lines and manifolds should be clearly marked with the identity of their contents and the direction of gas flow.
- When cylinders are no longer in use, shut the valves, relieve the pressure in the regulators, remove the regulators, and cap the cylinders.
- Make sure regulators are compatible with the gases they are being used with. Corrosive gases and carbon dioxide typically require regulators made of corrosive-resistant materials.
- Pressure regulators should be equipped with spring-loaded pressure relief valves to protect the low-pressure side. When used on cylinders of flammable, toxic, or otherwise hazardous gases, the relief valve should be vented to a hood or other safe location.
- Regulators used for corrosive gases should be removed immediately after use and flushed with dry air or nitrogen.
- Cylinder discharge lines should be equipped with approved check valves to prevent inadvertent contamination of cylinders that are connected to a closed system where the possibility of flow reversal exists.
- For small cylinders or lecture bottles, utilize a stand or other appropriate mechanism to secure the cylinder to a stable surface.

Transportation

- Always transport gas cylinders on wheeled cylinder carts with retaining straps or chains.
- Always transport lecture cylinders individually or in an approved carrier for transporting multiple cylinders.

Potential Leaks

- Only trained and designated persons may change or hook up gas cylinders.
- The laboratory faculty member must review and approve any new gas cylinder installation.
- Gas cylinders, hoses, tubing, and regulators must be maintained in good condition and replaced immediately if they become damaged or worn.
- Do not lubricate gas cylinder fittings and do not force tight fits.
- Open valves slowly, and do not stand directly in front of the gauges in case the gauge face blows out.

- Corrosive, toxic, and flammable gases must be connected with one continuous tube from the regulator to the apparatus.
- Cylinders, connections, and hoses should be checked regularly for leaks using an appropriate gas detector (if applicable), soapy water, or a 50 percent glycerin-water solution, can be used to look for bubbles.
- When the gas to be used in a procedure is a flammable, oxidizing, or highly toxic gas, the system should first be checked for leaks using an inert gas before introducing the hazardous gas.
- Laboratory personnel should never attempt to repair a leak at the junction of the cylinder valve and the cylinder or at the safety device. Contact the manufacturer or supplier for assistance.
- If a leak at the cylinder valve handle cannot be remedied by tightening a valve gland or a packing nut, contact the manufacturer or supplier for assistance.
- Use of internal bleed-type regulators should be avoided.

Empty Cylinder Disposal

- Whenever possible, only purchase cylinders (including lecture cylinders) that can be returned to the distributor.
- If cylinders cannot be returned to the distributor (including lecture cylinders), contact VEHS for proper disposal.

Special Requirements for Highly Toxic Gases

Examples of highly toxic gases include Bromine, Nitric oxide, Chlorine and Hydrogen Chloride.

- Contact the Chemical Hygiene Officer/VEHS to review plans for using highly toxic gases to ensure adequate safety measures are in place.
- Cylinders of highly toxic gases must be stored in a fume hood or a ventilated containment cabinet designed for storage of such gases.
- Gases should be mixed in the exhaust hood or cabinet to reduce concentrations in lines passing through occupied room space.
- Compatible metal tubing/piping without joints should be used to transport the gases across room space.
- Supply lines should be enclosed in an exhaust line (line within a line) connected to the exhaust system to capture, contain, and ventilate any leaks.
- An automatic shutoff should be used to turnoff gas supply in the event of a sudden loss of pressure in the supply line.
- A critical orifice should be used when possible to prevent free flow into the supply line.
- An alarm system should be used to detect leaks for routinely used highly toxic gases, or those with no or poor warning properties. The alarm level should be set at the permissible exposure level (PEL – found on the material safety data sheet) for that gas or lower.

- Order cylinders only when ready for experiments (check availability of gas).
- Order and store the minimum quantities required to perform research work.
- Only allow persons directly involved in the laboratory work and that have been advised of the hazards, controls, alarms, and emergency procedures in laboratories where these gases are being stored or used.
- Ensure that written procedures exist for checking for leaks in new cylinders and experimental setups, safely changing out gas cylinders, and responding to emergencies.

6.10 CRYOGENIC LIQUIDS

Direct skin or eye contact with cryogenic liquids can result in cold burns resulting in severe damage to tissues (similar to burn injuries) because of extremely low temperatures (-198 ^{o}C for liquid nitrogen) of these liquids. The most commonly used cryogenic liquid is liquid nitrogen. When handling these liquids follow these precautions:

- Wear a face shield and/or safety goggles to protect eyes
- Wear loose fitting gloves (for quick removal if liquid should splash into them) to protect hands.
- Minimize the contact time (even after wearing gloves)
- Wear protective clothing such as rubber aprons or overalls without pockets or cuffs
- Wear hightop shoes to protect against skin contact with the liquid falling on the floor.
- work with cryogenic liquids should be done in well-ventilated areas to prevent excessive buildup of gas concentration. Never use them in closed environment.

To transfer cryogenic liquids from a storage vessel, a suitable hose (that has a phase separator in place) ~3 feet long should be attached to the storage vessel. All transfers must be made to glass Dewar flasks that are shielded to protect the person making the transfer from possible implosion of the flask. Never use thermos flasks, as they will implode when used with liquid nitrogen. Withdraw liquid from the storage tank slowly at first because the interior of the transfer flask may still be at room temperature and rapid boil off will occur.

Be aware that the open containers of liquid nitrogen can be oxygen rich because oxygen condenses from the open atmosphere at liquid nitrogen temperatures.

In case of a cold burn, warm the contact area with warm water, body heat, or warm air (unlike for common burn injury where contact area is cooled). Do not rub or massage the affected area. Use mild soap and water to cleanse the area against infection. Seek medical help if needed.

6.11 VACUUM EQUIPMENT

Always wear safety glasses, goggles, or a face shield. The following precautions should be taken when glass vacuum containers are used:

- Tape the flask with electrical duct, adhesive tape to prevent exploded parts flying around.
- Secure the flask in a metal container large enough to hold the entire flask.
- Place an approved safety shield between the flask and personnel.

6.12 ULTRAVIOLET LAMPS

Contact VEHS with regard to use, cleaning, or installation of ultraviolet lamps. Avoid direct or indirect exposure by strong reflection to the eyes or skin. Eye protection (ultraviolet safety glasses with side shields, goggles with solid side pieces, or face shields) and skin protection (face shields, caps, gloves, gowns, etc) must be worn when working with these lamps. Exposure to skin will cause reddening (erythema) of skin. Painful inflammation of the conjunctiva, cornea, and iris are the symptoms of overexposure. These symptoms develop 3 to 12 hours following exposure. Unpleasant foreign body sensation accompanied by lacrimation (tearing) may be experienced (for a day or two). Overexposure to ultraviolet radiation should be reported to the supervisor and VEHS.

7.0 ROLES AND RESPONSIBILITES

7. 1 Dean of the College of Arts and Sciences

- Provides management support for the Chemical Hygiene Program.
- Ultimately responsible for ensuring that the College of Arts and Sciences complies with the TOSHA Laboratory Standard where it applies, by appointing the appropriate individuals responsible for the program.
- Supports University policies and training programs related to the use of appropriate environmental health and safety practices and facilities in research and teaching activities.
- Supports safety programs to implement environmental health and safety policies and procedures for safety and compliance in specific departments, institutes, centers, and units.

Reviews annual reports of activities, successes, and problems in environmental health and safety in the College of Arts and Sciences.

7.2 Vanderbilt Environmental Health Safety (VEHS) Department

VEHS provides a full spectrum of safety services and information to support the teaching and research in the Chemistry Department at Vanderbilt University. An overview of their services can be obtained from the website: http://www.safety.vanderbilt.edu. The following services are provided for maintaining safe working conditions in the Chemistry Department.

- Inform Chemistry personnel regarding institutional, local, state, and federal environmental heath and safety policies applicable to the research being performed in the chemistry department
- Provide Safety Training to Chemistry Department personnel

- Assist in the development of Chemical Hygiene Plan for Chemistry department
- Assist in developing safety protocols for hazardous chemicals and procedures
- Fume hood inspection and certification
- Hazardous waste collection and disposal
- Exposure monitoring and control
- Accident prevention and investigation
- Emergency assistance

7.3 Chemistry Department

Department Chair has the overall responsibility for ensuring that all work performed within the chemistry department complies with applicable health, safety and environmental requirements. The Chair may implement this responsibility through delegation to principal investigators, other faculty, committees, departmental administration or departmental staff deemed appropriate.

Faculty Members/Principal investigators are expected to collaborate with the Department Chair, Safety Committee and VEHS to identify the effective means to implement the Chemical Hygiene Plan in individual laboratories. Using their research expertise, they are expected to exchange information with the Safety Committee regarding chemical hygiene issues in the Department. The primary responsibility of the faculty member/PI is for chemical hygiene compliance in his/her laboratory. These responsibilities include:

- Ensuring that laboratory personnel are properly trained to implement the Chemical Hygiene Plan.
- Reducing the potential for exposure to hazardous chemicals and procedures by implementing safe work practices, providing protective equipment and implementing necessary engineering controls
- Informing laboratory personnel of the potential hazards of chemicals they use and means of avoiding hazardous incidents
- Maintaining material safety data sheets (MSDS's) for all chemicals in the laboratory. MSDS's must be maintained in the same area where the chemicals are stored and used.
- Maintaining a chemical inventory of all chemicals used and stored in the laboratory.
- Correcting any safety issues identified during the Laboratory Safety Audits promptly. (See the "Laboratory Safety Audits" section of this Chemical Hygiene Plan for more information.)
- Obtaining approvals, where required, prior to using hazardous chemicals or procedures
- Managing chemical waste properly
- Formulating Laboratory-specific safety plans and implementing them

Chemistry Chemical Hygiene Officer helps faculty members in the adaptation and implementation of the Chemical Hygiene Plan, thus maintaining a safe work environment and ensuring compliance with regulatory requirements. Uses feedback from Chemistry faculty members/principal investigators to satisfy the compliance issues. The responsibilities of Chemical Hygiene Officer include:

- Arranging Safety training to all chemistry personnel and maintaining pertinent records
- Coordinating with VEHS to advise the chemistry personnel on safe work procedures, protective equipment and engineering controls
- Coordinating with VEHS to assist Faculty members in developing safe procedures for new or lab-specific hazardous operations
- Arranging internal safety audits in the department

Laboratory workers are responsible for:

- Participating in all required safety trainings. (See the "Training" section of this Chemical Hygiene Plan for more information.)
- Reading and following this Chemical Hygiene Plan and other required Laboratory safety Techniques.
- To be aware of the hazards of the chemicals used in the lab work
- Conducting lab work in accordance with established safe procedures by following Chemical Hygiene Plan, Chemical Safety Protocols, lab-specific safety rules.
- Following safe work practices, and encouraging coworkers to do the same, by implementing personal protective equipment and engineering controls at all times
- Reporting any work-related injury or illness to supervising faculty member or their designee and seek prompt medical treatment, if necessary.
- Reporting unsafe conditions to supervising faculty member or Chemical Hygiene Officer or Department Chair.

APPENDIX A

OTHER HAZARDS POTENTIALLY ENCOUNTERED IN A CHEMISTRY LABORATORY

A.1 LASERS

Lasers are classified to describe the ability of the laser system to produce injury to personnel. The classes range from Class I (non-hazardous) to Class IV (most hazardous). Depending on the class of laser used, many requirements may apply including signage, written plans, designation of a Laser Safety Officer, and medical surveillance. Contact VEHS (322-2057) for information regarding requirements for specific lasers.

Laboratory Requirements

- If you are working with lasers, review the laser safety information and training available online at the VEHS website: www.safety.vanderbilt.edu/resources/cls_laser.htm
- Never look directly at the beam or pump source.
- Always wear goggles that offer protection against the specific wavelength of the laser in use. Multiple goggles may be required if multiple wavelengths are used. No available goggles protect against all laser wavelengths.
- Never view the beam pattern directly. Use an image converter or other safe, indirect means. To decrease reflecting hazard, do not aim by looking along the beam.
- Do not allow any objects that cause reflections to be present in or along the beam. Even buttons on clothing and polished screw heads can be dangerous.
- Keep a high general illumination level in areas where lasers are in operation. Low light levels cause dilation of the pupils and increase the risk of injury.
- Display appropriate warning signs in laser areas.
- Always terminate the laser beam with a light absorbing material or diffuse screen.
- Clearly mark the path of the beam and provide barriers to prevent accidental contact with eyes (for all lasers) and other body parts (for high power lasers).
- Provide an emergency shutdown or “kill” switch in an accessible location away from the laser.

A.2 REFRIGERATORS AND FREEZERS

The potential hazards posed by refrigerators and freezers include vapors from the contents, the possible presence of incompatible chemicals, spillage, and sparks creating an ignition source. As general precautions, laboratory refrigerators should be placed against fire-resistant walls, have heavy-duty cords, and preferably should be protected by their own circuit breaker. The contents of a laboratory refrigerator should be enclosed in unbreakable secondary containers. Vapors that escape from containers placed in a

refrigerator will accumulate and gradually be absorbed in the surrounding insulation. Therefore, a hazardous atmosphere could exist in refrigerators where flammable or toxic materials are stored. The placement of potentially explosive or highly toxic materials in a refrigerator is discouraged. If these materials must be placed in a refrigerator, the quantities should be kept to a minimum, the materials should be monitored regularly, and the refrigerator should be clearly labeled with an appropriate warning sign.

Laboratory Requirements

- Avoid storing highly toxic or explosive chemicals in refrigerators. If these materials must be stored in a refrigerator, minimize the quantity and clearly label the refrigerator with appropriate warning signs.
- Never place uncapped chemical containers in a refrigerator. Screw-caps should be used. Avoid the use of aluminum foil, plastic wrap, corks, and glass stoppers as capping devices.
- Do not use water-soluble ink to label chemical containers stored in a refrigerator. Use water-proof labels or cover labels with transparent tape.
- Be extra cautious in ensuring proper segregation of incompatible chemicals in refrigerators and freezers.
- Maintain an inventory of each refrigerator and freezer.

A.3 CENTRIFUGES

Laboratory Requirements

- Centrifuges must be properly installed and operated in accordance with the manufacturer's specifications.
- Centrifuges must be operated by trained and qualified lab personnel.
- The load must be balanced and the lid closed each time the centrifuge is operated.
- The operator must not leave the centrifuge until the full operating speed is achieved and the centrifuge appears to operating normally with no vibration.
- If vibration occurs, stop the run immediately, wait until the rotor stops, and check the load balance.
- Do not lean on or place items on the centrifuge while it is running.
- For use with flammable and/or hazardous materials, the samples should be contained in safety cups, sealed tubes, or safety rotors, and the centrifuge should be under a negative pressure and vented to an appropriate local exhaust system.

A.4 STIRRING AND MIXING DEVICES

Stirring and mixing devices commonly found in laboratories include stirring motors, magnetic stirrers, shakers, small pumps for fluids, and rotary evaporators for solvent removal. These devices are typically used in fume hoods, and it is important to operate them in a way that precludes the generation of electric sparks.

Laboratory Requirements

- Follow manufacturer's instructions.
- Use only spark-free induction motors.
- Ensure that these devices are plugged into a receptacle outside the fume hood and that they can be turned on or off by a switch located outside the hood in the event of an emergency.

A.5 OVENS

Laboratory Requirements

- Follow manufacturer's instructions.
- Volatile hazardous materials should not be dried in an oven unless the oven has continuous ventilation of the atmosphere inside the oven to an appropriate local exhaust system.
- Bimetallic strip thermometers are preferred for monitoring oven temperatures. Mercury thermometers should not be mounted on the tops of ovens such that the bulb hangs into the oven.
- Explosion proof ovens with rear blowout panels should be used for volatile materials.

A.6 HOT PLATES

Laboratory Requirements

- Follow manufacturer's instructions.
- Containers to be heated on hot plates should be no larger than the dimensions of the hot plate.
- Appropriate quality glass should be used for hot plate heating.
- Inspect all glassware for surface flaws or imperfections prior to use with hot plates.
- Flammable liquids should not be heated with hot plates that are not rated for flammables.
- Do not use ceramic top hot plates if they are scratched because they may shatter upon heating.

A.7 HEATING MANTLES

Laboratory Requirements

- Follow manufacturer's instructions.
- Always use heating mantles with a variable autotransformer to control the input voltage.
- Correctly match the mantle size with the vessel bottom shape and size.

A.8 OIL IMMERSION HEATING BATHS

Laboratory Requirements

- Follow manufacturer's instructions.
- Oil baths must be monitored with a thermal sensing device to ensure its temperature does not exceed the flash point of the oil being used. Oil baths left unattended must be equipped with an automatic shutoff device connected to the thermal sensor to prevent overheating.
- Hot oil circulators require the use of securely attached high temperature tubing, preferably flexible stainless steel with an inert liner.
- Oil type and quality should be reviewed periodically.
- Discard old oil baths after discoloration begins to occur or after several uses at high temperatures.

A.9 WATER BATHS

Laboratory Requirements

- Water baths must be checked for pitting, rusting, holes, and proper water level prior to use.
- The bath line should match the vessel solution line.
- For heating flammable liquids, monitor the temperature of the bath frequently. Since solvent polarity is likely to be different from that of water, special attention must be given to the proper rheostat setting for bath temperature.

A.10 VACUUM PUMPS

Laboratory Requirements

- If possible, use a facility vacuum system, water aspirator, or steam aspirator (each system protected by a suitable trapping device) for distillation or concentration operations involving significant quantities of volatile substances rather than using a mechanical vacuum pump.
- Suction lines from the system to the vacuum pump should be fitted with a cold trap to collect volatile substances from the system and to minimize the amount of material that enters the vacuum pump and dissolves in the pump oil.
- Output of vacuum pumps used to evacuate a system containing volatile toxic, corrosive, or flammable substances should be vented to an appropriate local exhaust system and passed through a scrubber or absorber device, if necessary.
- Drain and replace pump oil that has become contaminated. Dispose of all waste pump oil through VEHS.

A.11 ELECTRICAL EQUIPMENT

Laboratory Requirements

- Electric power receptacles for operations conducted in hoods must be located outside the hood. The cord should be routed under the air foil, if possible, so that the hood sash can be completely closed.
- Only trained and qualified personnel should perform repair or calibration work on electrical equipment.
- All appliances must have three-prong, grounded plugs, and all receptacles must be able to accept a three-prong plug and provide a ground connection. The receptacle should be oriented such that the ground wire is on top to protect the hot and neutral line from falling objects.
- Extension cords should only be used for temporary operations (less than one day). Standard three-conductor extension cords with sufficient rating for the equipment with an independent ground connection must be used.
- Equipment that is likely to be left running unattended (variable autotransformers, vacuum pumps, drying ovens, stirring motors, etc.) should be equipped with a fuse or other overload protection to disconnect the circuit if the equipment fails or is overloaded.
- Ensure all electric cords are in good condition and not frayed.
- Label defective electrical items to prevent their use while waiting for repair.
- Locate electrical equipment so as to minimize the possibility of spills into the equipment or flammable vapors carried into it.
- Turn off appliances before removing plugs from outlets to prevent voltage surges when the plug is reinserted.
- Minimize the condensation that may enter electrical equipment placed in a cold room or large refrigerator. Mount the equipment to the wall or vertical panel, if possible.
- Motor driven electrical equipment (vacuum pumps, mechanical shakers, stirring devices, and rotary evaporators) used with flammable materials or in areas where volatile flammable materials are present should be equipped with non-sparking induction motors or air motors instead of series-wound motors that use carbon brushes. The induction motors should meet Class 1, Division 2, Group C-D electrical standards.

A.12 CARCINOGENS (adapted from Norwestern University web page)

Substances either known to be human carcinogens or which may reasonably be anticipated to be carcinogens (suspect carcinogens) are listed below. Substances for which the evidence from human studies indicates that there is a causal relationship between exposure to the substance and human cancer are categorized as "Known carcinogens". Substances for which there is limited evidence of carcinogenicity in humans or sufficient evidence of carcinogenicity in experimental animals are categorized as which are "suspect carcinogens".

Known Carcinogens

1-(2-Chloroethyl)-3-(4-methylcyclohexyl)-1-nitrosourea (Methyl-CCNU)
1,3-Butadiene
1,4-Butanediol dimethanesulfonate (myleran)
2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD); "Dioxin"
2-Naphthylamine
4-Aminobiphenyl
4-Aminobiphenyl
Aflatoxins
Aflatoxins (naturally occurring mixtures of)
Alcoholic Beverage Consumption
Analgesic mixtures containing phenacetin
Arsenic and arsenic compounds
Arsenic and arsenic compounds
Asbestos
Asbestos
Azathioprine
Benzene
Benzidine (and Dyes Metabolized to Benzidine)
Beryllium and Beryllium Compounds
Bis(chloromethyl)ether(BCME) and technical grade chloromethyl methyl ether (CMME)
Cadmium and Cadmium Compounds
Chlorambucil
Chromium [VI] compounds
Cyclophosphamide
Cyclosporin A (Ciclosporin)
Diethylstilboestrol (DES)
Environmental Tobacco Smoke
Erionite
Estrogens, Steroidal
Ethylene Oxide
Etoposide
Gamma Radiation: see X- and Gamma (g)-Radiation
Melphalan
Methoxsalen with ultra-violet A therapy (PUVA)
Mineral oils, untreated and mildly-treated
MOPP - (combined therapy with nitrogen mustard, vincristine, procarbazine & prednisone) and other combined chemotherapy including alkylating agents
Mustard gas (Sulfur mustard)
Neutrons
Nickel compounds
Oestrogen replacement therapy
Oestrogens, nonsteroidal
Oestrogens, steroidal
Oral contraceptives, combined
Oral contraceptives, sequential
Phosphorus-32, as phosphate
Plutonium-239 and its decay products (may contain plutonium-240 and other isotopes), as aerosols
Radioiodines, short-lived isotopes, including iodine-131
Radionuclides, a-particle-emitting, internally deposited
Radionuclides, b-particle-emitting, internally deposited
Radium-224 and its decay products
Radium-226 and its decay products
Radium-228 and its decay products
Radon
Radon-222 and its decay products
Silica, Crystalline (Respirable Size)
Solar Radiation (See Ultraviolet Radiation Related Exposures)
Soots
Strong Inorganic Acid Mists Containing Sulfuric Acid
Sunlamps or Sunbeds, Exposure to (See Ultraviolet Radiation Related Exposures)
Talc containing asbestiform fibres
Tamoxifen
Thiotepa
Thorium dioxide
Tobacco products, smokeless and Tobacco smoke
Treosulfan
Ultraviolet Radiation, Broad Spectrum UV Radiation
Vinyl chloride
Wood Dust

Suspect Carcinogens

2-Aminoanthraquinone
[2-(5-nitro-2-furyl)vinyl]-1,3,4-oxadiazole
[2,3-b]indole)
1-(2-Chloroethyl)-3-cyclohexyl-1-nitrosourea (CCNU)
Direct Blue 6
Disperse Blue 1
Epichlorohydrin
Ethyl methanesulfonate

1,1-Dimethylhydrazine
1,2-Dibromo-3-choropropane (DBCP)
1,2-Dibromoethane (EDB)
1,2-Dichloroethane (EDC)
1,2-Diethylhydrazine
1,2-Diethylhydrazine
1,2-Dimethylhydrazine
1,2-Epoxybutane
1,3-Butadiene
1,3-Dichloropropene (technical grade)
1,3-Propane sultone
1,4-Dioxane
1,6-Dinitropyrene
1,8-Dinitropyrene
1-[(5-Nitrofurfurylidene)amino]-2-immidazolidinone
1-Amino-2-methylanthraquinone
1-Chloro-2-methylpropene
1-Hydroxyanthraquinone
1-Nitropyrene
2-(2-Formylhydrazino)-4-(5-nitro-2-furyl)thiazole
2,2-Bis(bromomethyl)propane-1,3-diol
2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD)
2,4,6-Trichlorophenol
2,4-Diaminoanisole
2,4-Diaminotoluene
2,4-Dinitrotoluene
2,6-Dimethylaniline(2,6-Xylidine)
2,6-Dinitrotoluene
2-Acetylaminofluorene
2-Amino-5-(5-nitro-2-furyl)-1,3,4-thiadiazole
2-Methyl-1-nitroanthraquinone
2-Methylaziridine (propyleneimine)
2-Nitroanisole
2-Nitrofluorene
2-Nitropropane
3-(N-Nitrosomethylamino)propionitrile
3,3-Diaminobenzidine
3,3'-Dichloro-4,4'-diaminodiphenyl ether
3,3'-Dichlorobenzidine
3,3'-Dimethoxybenzidine
3,3'-Dimethylbenzidine (ortho-Tolidine)
3,7-Dinitrofluoranthene
3,9-Dinitrofluoranthene
4-(N-Nitrosomethylamino)-1-(3-pyridyl)-1-butanone(NNK)
Ethylbenzene
Ethylene dibromide
Ethylene oxide
Ethylene thiourea
Etoposide
Formaldehyde
Fumonisin B1
Furan
Glu-P-1(2-Amino-6-methyldipyrido[1,2-a:3',2'-d]imidazole
Glu-P-2(2-Aminodipyrido[1,2-a:3',2'-d]imidazole
Glycidaldehyde
Glycidol
Griseofulvin
HC Blue No. 1
Heptachlor
Hexachlorobenzene
Hexachlorocyclohexanes
Hexachloroethane
Hexamethylphosphoramide
Hydrazine and hydrazine sulfate
Hydrazobenzene
Indeno [1,2,3,-cd]pyrene
IQ (2-Amino-3-methylimidazo[4,5-f]quinoline)
Iron-dextran complex
Isoprene
Lasiocarpine
Lead and lead compounds, inorganic
Magenta
MeA-a-C (2-Amino-3-methyl-9H-pyrido
Medroxyprogesterone acetate
MeIQ(2-Amino-3,4-dimethylimidazo[4,5-f]quinoline)
MeIQx(2-Amino-3,8-dimethylimidazo[4,5-f]quinoxaline)
Merphalan
Methyl methanesulfonate
Methylazoxymethanol & its acetate
Methylmercury compounds
Methylthiouracil
Metronidazole
Michler's ketone
Mirex
Mitomycin C
Mitoxantrone
Monocrotaline
N,N'-Diacetylbenzidine

4,4'-Diaminodiphenyl ether
4,4'-Methylene bis(2-chloroaniline) (MOCA)
4,4-Methylene bis(2-methylaniline)
4,4'-Methylene bis(n,n-dimethyl)benzeneamine
4,4'-Methylenedianiline
4,4-Methylenedianiline & its dihydrochloride
4,4-Oxydianiline
4,4'-Thiodianiline
4-Chloro-o-phenylenediamine
4-Chloro-o-toluidine
4-Nitropyrene
4-Vinylcyclohexene
4-Vinylcyclohexene diepoxide
5-(Morpholinomethyl)-3-[(5-nitrofurfurylidene)amino]
5-Methoxypsoralen
5-Methylchrysene
5-Nitroacenaphthene
6-Nitrochrysene
7H-Dibenzo(c,g)carbazole
A-a-C (2-Amino-9H-pyrido[2,3-b]indole)
Acetaldehyde
Acetamide
a-Chlorinated toluenes
Acrylamide
Acrylonitrile
Adriamycin
AF-2[2-(2-Furyl)-3-(5-nitro-2-furyl)acrylamide]
Aflatoxin M1
Amitrole
Amsacrine
Androgenic (anabolic) steroids
Antimony trioxide
Aristolochic acids
Auramine, technical grade
Azacitidine
Azaserine
b-Butyrolactone
Benz(a)anthracene
Benzidine-based dyes
Benzo(a)pyrene
Benzo(b)fluoranthene
Benzo(j)fluoranthene
Benzo(k)fluoranthene
Benzofuran
Benzyl violet 4B
N-[4-(5-Nitro-2-furyl)-2-thiazolyl]acetamide
Nafenopin
Naphthalene
N-Ethyl-N-nitrosourea
Nickel, metallic and alloys
Niridazole
Nitrilotriacetic acid and its salts
Nitrobenzene
Nitrofen
Nitrogen mustard
Nitrogen mustard N-oxide
Nitromethane
N-Methyl-N'-nitro-N-nitrosoguanidine (MNNG)
N-Methyl-N-nitrosourea
N-Methyl-N-nitrosourethane
N-Nirtosidiethylamine
N-Nitrosodiethanolamine
N-Nitrosodimethylamine
N-Nitrosodi-n-butylamine
N-Nitrosodi-n-propylamine
N-Nitrosomethylethylamine
N-Nitrosomethylvinylamine
N-Nitrosomorpholine
N-Nitroso-n-ethylurea
N-Nitroso-n-methylurea
N'-Nitrosonornicotine
N-Nitrosophyrrolidine
N-Nitrosopiperidine
N-Nitrososarcosine
Norethisterone
o-Aminoazotoluene
o-Anisidine and o-anisidine HCl
Ochratoxin A
Oil Orange SS
ortho-Anisidine
o-Toluidine and o-toluidine-HCl
Oxazepam
Oxymetholone
Palygorskite (attapulgite) (long fibres, > 5 micrometers)
p-Aminoazobenzene
Panfuran S (containing dihydroxymethylfuratrizine)
para-Chloroaniline
para-Dichlorobenzene
p-Cresidine
p-Dimethylaminoazobenzene

Berylliun and certain Be compounds
Bischloroethyl nitrosourea (BCNU)
Bitumens, extracts of steam-refined & air-refined
Bleomycins
b-Propiolactone
Bromodichloromethane
Butylated hydroxyanisole (BHA)
C.I. basic red 9 monohydrochloride
Caffeic acid
Captafol
Carbon black
Carbon tetrachloride
Carrageenan, degraded
Catechol
Chlordane
Chlordecone (Kepone)
Chlorendic acid
Chloroform
Chlorophenols
Chlorophenoxy herbicides
Chloroprene
Chlorothalonil
Chlorozotocin
CI Acid Red 114
CI Direct Blue
Cisplatin
Citrus Red No 2
Cobalt and cobalt compounds
Creosotes
Cupferron
Dacarbazine
Dantron (Chrysazin; 1,8-Dihydroxyanthraquinone)
Daunomycin
DDT
Di(2-ethylhexyl)phthalate
Dibenz(a,h)acridine
Dibenz(a,h)anthracene
Dibenz(a,j)acridine
Dibenzo(a,e)pyrene
Dibenzo(a,h)pyrene
Dibenzo(a,i)pyrene
Dibenzo(a,l)pyrene
Dichloromethane
Diepoxybutane
Diethyl sulfate
Diglycidyl resorcinol ether
Dihydrosafrole
Phenacetin
Phenazopyridine and HCl-salt
Phenobarbital
Phenolphthalein
Phenoxybenzamine hydrochloride
Phenyl glycidyl ether
Phenytoin
PhIP(2-Amino-1-methyl-6-phenylimidazo[4,5-b]pyridine)
Polybrominated biphenyls (PBBs)
Polychlorinated biphenyls (PCBs)
Polychlorophenols and their sodium salts
Ponceau 3R
Ponceau MX
Potassium bromate
Procarbazine and HCl-salt
Progestins
Progestogen-only contraceptives
Propylene oxide
Propylthiouracil
Refractory ceramic fibres
Reserpine
Riddelliine
Safrole
Selenium sulfide
Silica, crystalline
Sodium o-phenylphenate
Sterigmatocystin
Streptozotocin
Styrene
Styrene-7,8-oxide
Sulfallate
t-2-[(Dimethylamino)methylimino]-5-
Tetrachloroethylene
Tetrafluoroethylene
Tetranitromethane
Thioacetamide
Thiouracil
Thiourea
Toluene diisocyanates
Toxaphene (Polychlorinated camphenes)
Trichlormethine (Trimustine hydrochloride)
Tris(1-aziridinyl)phosphine sulfide
Tris(2,3-dibromopropyl)phosphate
Trp-P-1(3-Amino-1,4-dimetyl-5H-pyrido[4,3-b]indole)
Trp-P-2(3-Amino-1-methyl-5H-pyrido[4,3-b]indole)
Trypan blue
Uracil mustard

Diisopropyl sulfate
Dimethyl sulfate
Dimethylcarbamoyl chloride
Dimethylvinyl chloride
Direct Black 38 (benzidine derived azo dye)
Urethane
Vinyl acetate
Vinyl bromide
Zalcitabine
Zidovudine (AZT)

A.13 INCOMPATIBLE CHEMICALS

Chemicals and their incompatibilities (adapted from Cornell University and University of Kentucky web pages)

Chemical	Incompatibilities
Acetic acid	Chromic acid, nitric acid, hydroxyl compounds, ethylene glycol, perchloric acid, peroxides, permanganates
Acetic anhydride	Chromic acid, nitric acid, hydroxyl-containing compounds, ethylene glycol, perchloric acid, peroxides and permanganates
Acetylene	Chlorine, bromine, copper, fluorine, silver, mercury, halogens
Acetone	Concentrated nitric and sulfuric acid mixtures
Alkali and alkaline earth metals (such as lithium, sodium, potassium,cesium, magnesium,calcium), powdered aluminum	Water, carbon tetrachloride or other chlorinated hydrocarbons, carbon dioxide, halogens. Do not use water, foam or dry chemical on fires involving these metals.
Aluminum alkyls	Halogenated hydrocarbons, water
Ammonia (anhydrous)	Mercury, chlorine, calcium hypochlorite, iodine, bromine, hydrofluoric acid (anhydrous), silver, chlorine dioxide
Ammonium nitrate	Acids, powdered metals, flammable liquids, chlorates, nitrites, sulfur, finely divided organic combustible materials
Aniline	Nitric acid, hydrogen peroxide
Arsenical materials	Any reducing agent
Azides	Acids
Benzoyl peroxide	Chloroform, organic materials
Bromine	Ammonia, acetylene, butadiene, butane and other petroleum gases, sodium carbide, turpentine, benzene and finely divided metals, methane, propane, hydrogen
Calcium carbide	Water (see also acetylene)
Calcium hypochlorite	Methyl carbitol, phenol, glycerol, nitromethane, iron oxide, ammonia, activated carbon.
Calcium oxide	Water
Carbon (activated)	Calcium hypochlorite, all oxidizing agents
Carbon tetrachloride	Sodium
Chlorates	Ammonium salts, acids, powdered metals, sulfur, finely divided organic or combustible materials

Chlorine	Ammonia, acetylene, butadiene, butane, methane, propane (or other petroleum gases), hydrogen, sodium carbide, benzene, finely divided metals, turpentine
Chlorine dioxide	Ammonia, methane, phosphine, hydrogen sulfide
Chlorosulfonic acid	Organic materials, water, powdered metals
Chromic acid, Chromium trioxide and chromium	Acetic acid, naphthalene, camphor, glycerin, turpentine, alcohol and other flammable liquids, paper or cellulose
Copper	Acetylene, hydrogen peroxide
Cumene hydroperoxide	Acids (organic or inorganic)
Cyanides	Acids
Ethylene oxide	Acids, bases, copper, magnesium perchlorate
Flammable liquids	Ammonium nitrate, chromic acid, hydrogen peroxide, nitric acid, sodium peroxide, halogens
Fluorine	Almost all oxidizable substances
Hydrides	Water, air, carbon dioxide, chlorinated hydrocarbons.
Hydrocarbons (such as butane, propane, benzene)	Fluorine, chlorine, chromic acid, sodium peroxide
Hydrocyanic acid	Nitric acid, alkali
Hydrofluoric acid (anhydrous)	Ammonia (aqueous or anhydrous), organic peroxides
Hydrogen peroxide	Copper, chromium, iron, most metals or their salts, alcohols, acetone, organic materials, aniline, nitromethane, combustible materials
Hydrogen sulfide	Fuming nitric acid, oxidizing gases
Hydroxylamine	Barium oxide, lead dioxide, phosphorus pentachloride and trichloride, zinc, potassium dichromate.
Hypochlorites	Acids, activated carbon
Iodine	Acetylene, ammonia (aqueous or anhydrous), hydrogen
Maleic anhydride	Sodium hydroxide, pyridine and other tertiary amines.
Mercury	Acetylene, fulminic acid, ammonia
Nitrates	Sulfuric acid, Acids, metal powders, flammable liquids, chlorates, sulfur, finely divided organics or combustibles.
Nitric acid (concentrated)	Acetic acid, aniline, chromic acid, hydrocyanic acid, hydrogen sulfide, flammable liquids, flammable gases, copper, brass, any heavy metals
Nitrites	Acids
Nitroparaffins	inorganic bases, amines
Oxalic acid	Silver, mercury
Oxygen	Oils, grease, hydrogen: flammable liquids, solids or gases
Perchlorates	Acids

Perchloric acid	Acetic anhydride, bismuth and its alloys, alcohol, paper, wood, gease, oils
Peroxides, organic	Acids (organic or mineral), avoid friction, store cold
Phosphorus (white)	Air, oxygen, alkalies, reducing agents
Phosphorus pentoxide	Propargyl alcohol
Potassium	Carbon tetrachloride, carbon dioxide, water
Potassium chlorate	Sulfuric and other acids
Potassium perchlorate (see also chlorates)	Sulfuric and other acids
Potassium permanganate	Glycerol, ethylene glycol, benzaldehyde, sulfuric acid
Selenides	Reducing agents
Silver	Acetylene, oxalic acid, tartartic acid, ammonium compounds, fulminic acid
Sodium	Carbon tetrachloride, carbon dioxide, water
Sodium amide	Air, water
Sodium nitrite	Ammonium nitrate and other ammonium salts
Sodium oxide	Water, any free acid
Sodium peroxide	Ethyl or methyl alcohol, glacial acetic acid, acetic anhydride, benzaldehyde, carbon disulfide, glycerin, ethylene glycol, ethyl acetate, methyl acetate, furfural
Sulfides	Acids
Sulfuric acid	Chlorates, perchlorates, permanganates, organic peroxides. Potassium chlorate, potassium perchlorate, potassium permanganate (similar compounds of light metals, such as sodium, lithium.)
Tellurides	Reducing agents.
Zirconium	Prohibit water, carbon tetrachloride, foam and dry chemical on zirconium fires.

APPENDIX B

CHEMICAL SAFETY PROTOCOL

Date:
Faculty Member:

Room & Building:

Phone Number:

Section 1: Select which aspect of laboratory operations this document covers. (*Check One*)

☐ *Process/Procedure*

☐ *Specific Hazardous Chemical/Gas*

☐ *Hazardous Chemical Class,*

List Class:

Section 2: Describe Process/Procedure, Specific Hazardous Chemical/Gas or Hazardous Chemical Class.

******For* **Process/Procedure,** *please include a list of chemicals and/or gases used, as well as, a short summary of the procedural steps.*

Section 3: Describe Potential Hazards.

Section 4: Select and List Required Personal Protective Equipment (PPE). (Check ALL That Apply). *List specific type(s), where to obtain, how to care for, and when that the PPE need be replaced.*

☐ **Gloves**	**Type(s):** **Obtained From:** **Care For/When Replaced:**
☐ **Eye/Face Protection**	**Type(s):** **Obtained From:** **Care For/ When Replaced:**

☐ **Body**	**Type(s)**: **Obtained From:** **Care For/ When Replaced:**
☐ **Respiratory***	**Type(s):** **Obtained From:** **Care For/ When Replaced:**

* **ALL USAGE OF PERSONAL RESIRATORY PROTECTION MUST BE APPROVED BY VEHS (2-2057)**

5. Select Required Engineering and Ventilation Controls

Select Required Controls from Provided Fields:

If either '**Other**' or '**None**' is selected above, or *if special considerations/conditions need be applied*, list them and reasons why that practice applies in the space provided below:

Section 6: List Special Handling and Storage Requirements.

Section 7: List Spill, Accident, and Emergency Decontamination Procedures.

Section 8: List Routine Equipment Decontamination Procedures.

Section 9: List Procedures for Waste Disposal.

Protocol Review:

Form Completed by:		Date:	
Principal Investigator:		Date:	
VEHS:		Date:	

Chemical Hygiene Officer:		Date:	

How to Use This Form to Create
Chemical Safety Protocols for Your Laboratory

Section 1: Select which aspect of operations this document covers (Check One).

Check the box that best describes what aspect of your laboratories operations that this protocol covers. With all sections of the form, look at the provided examples to provide guidance of how to complete the protocols. Selection of which type best covers your specific aspect is broken down below:

- **Process/Procedure:** A process or procedures that you are performing that may consist of multiple hazards and/or specific safety procedures and/or equipment.

- **Chemical:** A chemical that presents unique precautions and issues to laboratory operations. Chemicals that are extremely flammable, extremely toxic, or select carcinogens fall into this category.

- **Hazard Class**: A group of chemicals used in the lab that have similar properties, hazards, and safety precautions. Because many of the laboratories contain a wide variety of chemicals, it is acceptable to define these as classes of chemicals (i.e. corrosives, flammable, oxidizer, etc.).

When deciding whether to write a Chemical Safety Protocol (CSP) for a process/procedure, a specific chemical, or a chemical hazard class, keep in mind that the idea is to ***ensure that all processes and procedures involving physical hazards or hazardous chemicals are covered by CSP's, while at the same time, developing the least amount of CSP's***. With this in mind, it is important to note that multiple processes may be covered by one CSP if the safety information on the form is applicable to all processes listed on the form. For example, a lab may have many different processes for organic distillation that differ slightly in how they are performed, but the safety information for each process is the same or only differs slightly. In this case, one CSP may be used for all organic distillation processes with any slight variations for particular chemicals of note, noted on the form.

Section 2: Describe Process, Hazardous Chemical or Hazard Class.

Describe the process or type of processes that include the usage of hazardous materials or equipment. General terms, such as 'extraction' or 'distillation', are acceptable. More detailed descriptions of an individual process such as, "dissociation of environmental

substrates for isotopic analysis of actinides by alpha spectrometer" are acceptable as well. All major processes performed within a faculty member's laboratory area must be accounted for. For each major process in your area(s), use a separate copy of the '**Chemical Safety Protocol'** form.

If describing a class of chemicals, please include examples of some specific chemicals used in the laboratory for that class.

Section 3: Describe Potential Hazards.

Note potential hazards for the process. Hazards may include chemical exposure, fire, explosion, thermal hazards, electrical, crushing, etc. For ***Process/Procedure***, please list chemicals or gases that are used and then describe the hazards associated with that process. If MSDS sheets are unavailable for a unique chemical created in the lab, then include an additional chemical that is similar in properties/hazards as an example.

Section 4: Select and List Required Personal Protective Equipment. (Check ALL That Apply)

For your protocol, identify personal protective equipment (PPE) that is necessary for reasonably safe laboratory operations. Categories of PPE are gloves, eye/face protection, body, and respiratory. Note in the space beside the category specific types of at that type of PPE that are required. Glove examples would be disposable nitrile, etc. Also indicate where these items are obtained from, as well as, the care of and when to replace PPE items.

Section 5: Select Required Engineering and Ventilation Controls

List any engineering controls from the drop down menus in the provided fields that are used for this protocol to reduce exposures to hazardous chemicals or physical agents. If 'Other' or 'None' is selected or special conditions need apply to another type listed, describe that equipment or conditions, and reasons for that condition, etc. in the field provided.

Section 6: Describe Special Handling and Storage Requirements.

List requirements for storage and handling of hazardous materials used that are being described in this protocol. Include specific storage areas, special containment devices, etc. For example, flammable chemicals and gases should be stored in flammable cabinets.

Section 7: Describe Spill, Accident, and Emergency Decontamination Procedures.

List all procedures that would be used in your area to respond to emergency conditions which may result from use of this material(s), hazardous chemical class, or

process/procedure. Examples include calling VUPD at 911, use of and collection of compatible absorbent materials for free liquids, etc.

Section 8: List Routine Equipment Decontamination Procedures.

List procedures to decontaminate glassware, equipment, and areas used. Examples would be using soap and water, using an acetone rinseate, etc.

Section 9: List Procedures for Waste Disposal.

List how waste materials will be collected and properly disposed of. Examples of this include broken glass into broken glass containers, collecting acetone used to decontaminate glassware into appropriate and properly tagged waste containers, etc.

Protocol Review:

When you have completed the form, the protocol should be reviewed and approved by the faculty member you are performing this process for. When the protocol is approved by your faculty member, please save this document in the following format and forward to Chemistry's Chemical Hygiene Officer and the Laboratory Compliance Coordinator from Vanderbilt Environmental Health & Safety (VEHS) for review:

Faculty Member-User-Protocol.doc
(i.e. Porter-Pujols-Distillation.doc)

APPENDIX C

LABORATORY SAFETY AUDIT CHECKLISTS

Audit Checklists will be inserted here at a later time.

APPENDIX D

SAFETY TRAINING AND AWARENESS CERTIFICATION FORM
Undergraduate Students Performing Research
VANDERBILT DEPARTMENT OF CHEMISTRY

As an undergraduate student performing research in Chemistry Department laboratories, you are required to receive laboratory safety training and understand and abide by the Chemistry Department safety policies and procedures.

By signing this certification form, you acknowledge the following:

- You have received general laboratory safety training provided by the Vanderbilt Environmental Health and Safety Department.
- You have received laboratory-specific safety training for the lab you are working in or have confirmed that none is required.
- You have received and read a copy of the American Chemical Society Publication, "Safety in the Academic Chemistry Laboratories, Volume 1 or 2," and you understand and will abide by the safety guidelines and policies contained therein.
- You will never work alone in a laboratory. You should always be supervised by your faculty supervisor or their designated representative.
- You will not perform any experiments/processes or operate any equipment for which you are not authorized or trained.
- You will wear appropriate attire while working in the lab. Clothing should cover the legs. No shorts, cutoffs, miniskirts, open-toed shoes, shoes with fabric/woven top, high heels, or sandals should be worn in a laboratory.
- You will wear the prescribed personal protective equipment (lab coat, safety goggles, etc.) appropriate for the work being performed and will use it in its intended manner.
- You will not eat, drink, chew gum, consume tobacco products, apply cosmetics, or prepare or store food or tobacco products in the laboratory – this includes the desk areas in the labs.
- You will work in a safe manner and take all necessary precautions appropriate for the hazards of the processes you are conducting.
- You will report any workplace injury or illness to your faculty supervisor or their designee and seek prompt medical attention, if necessary.
- You will report to your faculty supervisor any work practices or working conditions that you believe are hazardous to your health or the health of others.

Student Name (print): _____

Date: _____

Signature: _____

APPENDIX E

SUMMARY OF LABORATORY REQUIREMENTS

Training

- Annual training on general lab safety and the contents of the Chemical Hygiene Plan is required for all faculty, students, and staff that work in or supervise people that work in chemical laboratories. This training is provided by VEHS and documentation of attendance is maintained by the Chemical Hygiene Officer.
- Faculty members must provide annual lab-specific safety training for all workers performing research under their supervision. This training should be documented and filed by the faculty member.
- Faculty members, lab managers, and/or supervisors must ensure that all lab workers receive on-the-job training prior to performing specific processes or working with lab equipment for the first time.
- Additional specific training may be required for work with radioactive materials or equipment, animals, biological materials, lasers, or other special lab equipment. Contact VEHS (322-2057; http://www.safety.vanderbilt.edu) for information on training requirements for working with these materials.

Chemical Safety Protocols

- Develop Chemical Safety Protocols (CSP's) to address all procedures involving physical hazards or hazardous materials using the CSP form in this Chemical Hygiene Plan (Appendix B). Consult with the Chemical Hygiene Officer prior to developing CSP's to obtain copies of CSP's already completed that may be applicable.
- Utilize students or lab workers responsible for the process to develop the CSP's whenever possible.
- Provide and train laboratory staff on the applicable CSP's prior to allowing them to conduct research.
- Submit copies of completed CSP's to the Chemical Hygiene Officer.

General Laboratory Ventillation

- Do not block supply or exhaust registers.
- Do not place equipment in the laboratory in such a way as to block airflow from the ventilation system.
- Report any ventilation problems to the Plant Operations HAR shop (343-9675) immediately.

Chemical Fume Hoods

- Perform all work that may result in the generation or release of hazardous or offensive gases or vapors in a chemical fume hood. As a rule of thumb, use a chemical fume hood or other exhaust device when working with any appreciable volatile substance with a threshold limit value (TLV) of less than 50 parts per

million (ppm), carcinogens, reproductive toxins, and highly toxic chemicals. The TLV for the chemical can be obtained from the material safety data sheet.
- Ensure the hood is working properly by checking the air flow indicator prior to use. Digital flow indicators should show a reading between 80 and 120 feet per minute and analog indicators should display a green light.
- Minimize the number of items stored in the hood and ensure that at least 50% of the working surface is clear.
- Items stored in the hood should be placed at least 6 inches into the hood from the face, placed to the sides of the hood, and, if possible, elevated 2 to 3 inches above the surface using shelving to minimize disruption to the airflow.
- Keep the vertical sash height at 18 inches or less from the working surface while working in the hood to ensure optimum flow rate and to protect yourself from potential chemical splashes or explosions. Horizontal sashes should be set to the minimum opening required to perform work.
- Work at least 6 inches into the hood from the face to minimize the potential for fumes to escape.
- Keep laboratory doors and windows closed and limit movement in front of the hood during use to minimize disruption to the airflow.
- Keep the sash closed when fume hood is not being used.
- Contact VEHS if you are planning on using perchloric acid, carcinogens, reproductive toxins, and/or highly toxic chemicals (see definitions) in your fume hood to see if any special precautions must be taken.
- Notify the Chemical Hygiene Officer or department Chair if the fume hoods available are not sufficient for your research work.

Contact Plant Operations (343-9675) if your fume hood is not working properly.

Globe boxes and other local exhaust ventillation

- Design, install, and maintain glove boxes in accordance with manufacturer's recommendations and applicable government and industry standards.
- Contact VEHS if you are planning on using carcinogens, reproductive toxins, and/or highly toxic chemicals (see definitions) in your glove box to see if any special precautions must be taken.

Emergency response equipment

- Never block pathways or access to emergency showers, eyewash stations, fire extinguishers, chemical response kits, or first aid kits.
- Contact the Plant Operations Plumbing shop for problems with the emergency showers, eyewash stations, or fire extinguishers (322-2622).
- Contact the Chemical Hygiene Officer to obtain or replenish a first aid kit or spill response kit.

Laboratory Attire

- Wear clothing that covers the legs and that is easily removable in the event of an accident.

- Avoid wearing loose or flowing clothing and clothing made of flammable polymeric fabrics.
- Wear shoes without high heels that are closed-toed, closed-heeled, and not made of woven or porous fabrics.
- Secure long hair.
- Store jewelry such as rings, bracelets, and watches in your desk while working in the lab.

Personal Protective Equipment

- Select personal protective equipment (PPE) for a process based on an evaluation of the potential exposure hazards. The PPE required for a process should be specified in the Chemical Safety Protocol.
- Always wear the specified PPE for a process.
- Use safety glasses for eye protection against projectiles.
- Use safety goggles for eye protection against chemical splashes or fine particulate matter.
- Use face shields in addition to safety goggles for protection of the face against chemical splashes.
- If contact lenses are worn in the laboratory, safety goggles should also be worn.
- Ensure that all lab visitors have at least safety glasses on at all times while in the lab.
- Lab coats are recommended for body protection while working in the lab.
- Lab coats are recommended to be buttoned at all times.
- Contaminated lab coats are recommended to be given for professional cleaning..
- Chemistry department is evaluating the in-house professional laundry service for lab coats.
- Use chemically resistant, non-flammable laboratory aprons for processes that involve a reasonable risk of splashing caustic, corrosive or highly toxic chemicals that can be absorbed through the skin onto the body.
- Use disposable nitrile gloves for general lab operations.
- Latex gloves are not recommended for use with chemicals.
- Select the proper glove material (nitrile, butyl rubber, neoprene, viton, etc.) for a particular chemical by consulting the MSDS for the chemical or a glove compatibility chart provided by the manufacturer. Specify the appropriate glove material in the Chemical Safety Protocol.
- Select the proper glove type (thickness, length, etc,) for a particular process by evaluating the task and possible splash, immersion and contact hazards. Specify the appropriate glove type in the Chemical Safety Protocol.
- Remember that gloves are an expendable item and should be discarded and replaced within safe permeation times listed on the manufacturer's tables.
- Inspect gloves prior to use.
- Disposable gloves are not recommended for reuse.
- Thoroughly rinse non-disposable gloves prior to removal.

- Dispose of non-disposable gloves periodically.
- Wash hands after removing gloves.
- Never wear a respirator without prior approval from VEHS.

Personal Hygiene

- Do not prepare, store (even temporarily), or consume food or beverages in the laboratory. This includes storage areas and refrigerators.
- Do not smoke, consume or store tobacco products in the laboratory. Additionally, be aware that tobacco products in open packages can absorb chemical vapors.
- Do not chew gum or apply cosmetics in the laboratory.
- No evidence of food or tobacco consumption should be present in the laboratory. This means that laboratory desks, benches, trash cans, etc. should not have any wrappers or other empty food containers that indicate that these items might have been consumed in the lab.
- Do not store or use food preparation and storage equipment (such as microwaves, refrigerators, and coffee makers) in the laboratory.
- Refrigerators used for chemical storage should be conspicuously labeled on the outside with the words, "Chemical Storage Only."
- Glassware or utensils used for laboratory operations should never be used to contain or prepare food or beverages.
- Wash hands and arms thoroughly before leaving the laboratory, even if gloves and a lab coat have been worn.
- If contact lenses are worn in the laboratory, safety goggles should also be worn.
- Contaminated lab coats are recommended to be given for professional cleaning.
- Never wear or bring lab coats or aprons into areas where food is consumed, prepared, or stored.
- Never pipette by mouth. Always use a pipette aid or suction bulb.
- Never wear gloves into non-laboratory areas including elevators.
- Confine long hair and loose clothing while working in the laboratory.

Housekeeping

- Keep aisle ways, exits, halls, stairways, and access to emergency equipment or controls free from clutter or obstructions. Lack of storage space is not an excuse for blocking aisle ways. Contact your supervisor or the Chemical Hygiene Officer if more storage space is needed.
- Keep lab benches, hoods, tables, etc. clean and uncluttered.
- After an experiment or class is completed, clean workspaces (including bench tops and floors), dispose of waste properly, and return chemicals and equipment to their proper storage locations.
- Dispose of glass in an appropriate broken glass container and never in a regular trash can.
- Clean up spills immediately in accordance with the chemical response procedures for the laboratory.
- Keep floors and walkways dry and free from slip/trip/fall hazards at all times.
- Place electric cords, tubing, cables, etc. above walk spaces and thresholds.

- Work areas should be inspected at the beginning and end of each day to ensure proper housekeeping.

Working in the Laboratory

- Never work alone in the laboratory without making provisions. Individuals working alone in separate laboratories should make arrangements to check on each other periodically. For hazardous processes, ensure that someone else is aware of what you are doing and is in constant contact with you. For non-hazardous processes, the presence of someone else in the vicinity is adequate.
- Undergraduate students should never work alone and should always be supervised by their faculty member or a designated representative while working in a laboratory. Undergraduate students must meet the requirements of and sign a "Safety Training and Awareness Certification" form prior to performing research work in a lab.
- Do not engage in horseplay or practical jokes and avoid distracting or startling other workers in the laboratory.
- Use laboratory equipment only for its designated purpose.
- Do not allow children or pets in laboratories where hazardous materials are stored or used.
- Make sure that all visitors to the laboratory are in proper attire and necessary personal protective equipment. Safety glasses are the minimum personal protective equipment required for visitors in all chemical laboratories.
- Make sure you are familiar with the chemicals you are working including their hazardous properties and signs and symptoms of exposure.
- Ensure proper exhaust ventilation is present for work with chemicals.
- Handle and store laboratory glassware with care to avoid damage. Damaged glassware should be disposed of immediately.
- Use extra care with Dewar flasks and other evacuated glass apparatus. Shield or wrap them to contain the chemicals and glass fragments should implosion occur.
- Ensure that written procedures including a Chemical Safety Protocol exists and have been reviewed and approved for any new procedure.
- Only well understood processes will be allowed to run unattended. When unattended operations are required, leave the lights on, place a sign on the door, and provide containment for any hazardous substances in the event of failure of the system.
- Never smell or taste a chemical.
- Apparatus that may discharge or release hazardous vapors, gases, or dust (vacuum pumps, distillation columns, etc.) must be vented into an appropriate local exhaust device.
- Store items that weigh more than 10 pounds or that are awkward to lift due to their size or shape on shelves at chest level or below.

Laboratory security

- Keep lab doors locked anytime no one is present in the lab. This includes after hours. Do not rely on building security to restrict access to the labs. Access must be restricted at the lab door.
- Question strangers in the lab.
- Require lab staff to have identification or proper credentials with them at all times while in the lab.
- If necessary, lock cabinets, refrigerators, or freezers where hazardous materials are stored for additional security.
- Restrict/control access to the lab by limiting the number of people with keys and combinations.

Work requiring prior approval

- Working with particularly hazardous substances (as defined by this Chemical Hygiene Plan), animals, hazardous biological materials, recombinant DNA, human or primate biological materials, radioactive materials, and lasers requires approval from the Chemical Hygiene Officer/VEHS.

Chemical Procurement and Distribution

- Inspect all chemical containers and gas cylinders prior for leaks or defects prior to removing them from the Chemistry stockroom.
- Transport chemical from the Chemistry stockroom to the laboratory in a safe manner utilizing secondary containment for liquid chemicals.
- Transport compressed gas cylinders with valve covers securely fastened using an appropriate gas cart and strap or chain the cylinder to the cart securely.
- Wear appropriate personal protective equipment when transporting chemicals and cylinders.

Chemical Hazard Information

- Faculty members must ensure that lab workers have access to information about the hazardous materials used and stored in the lab.
- Material safety data sheets (MSDS's) for all chemicals used or stored in the lab must be maintained in the lab. These must be either in paper form in a binder or in electronic form on a disk or local hard drive.
- Lab workers need to know the contents of the TOSHA Laboratory Standard and its appendices which are available on the Department website.
- Incoming chemicals must not have their labels removed or defaced.
- Chemical containers must be labeled with the common name of the chemical. Abbreviations, formulas, and/or symbols should not be used as the sole means to identify a chemical.
- Inventories of hazardous chemicals used and stored in the lab must be maintained including the chemical name, physical state, quantity, and general location.
- Chemicals synthesized in the lab must be evaluated to determine if they are hazardous based on available data. If they are hazardous or a hazardous determination cannot be made, they must be addressed in accordance with this Chemical Hygiene Plan.

- Chemicals developed in the lab for use outside of the lab must comply with the OSHA/TOSHA Hazard Communication Standard including the requirements for preparation of material safety data sheets and labeling.

Chemical Storage in the laboratories

- Keep quantities of chemicals stored in the laboratory to a minimum.
- Store all chemicals in a clean, dry location away from sunlight, extreme temperature changes, and sources of ignition.
- Segregate chemicals by hazard class such that there is no reasonable potential for incompatible chemicals or chemical vapors to mix.
- Label all peroxide forming chemicals (ethers and tetrahydrofuran) with the date received and date opened. For these chemicals, dispose of opened containers within 6 months and unopened containers within one year.
- Store highly toxic, corrosive, and flammable chemicals below eye level. These chemicals should not be stored above the first shelf on the lab benches.
- Do not store chemicals that are not actively being used in fume hoods or on bench tops.
- Do not store liquid, hazardous chemicals near sink, floor, or hood drains unless secondary containment is provided to prevent spills from entering the drains.
- Store volatile toxics and odoriferous chemicals in a ventilated cabinet.
- Store all flammable liquids not actively being used in approved flammable materials storage rooms or cabinets and away from potential ignition sources.
- Flammable liquids in use that are stored outside of a flammable liquid cabinet (including wastes) must be kept to a minimum and must never exceed the lesser of 2 gallons per square foot of lab space or 150 gallons.
- Glass containers used to store flammable liquids must not exceed 4 liters.
- Total quantities of flammable liquids (including wastes) stored in the lab (including those stored in flammable cabinets) should be kept to a minimum and must never exceed 4 gallons per square foot of lab space or 300 gallons.
- Chemical storage areas such as refrigerators, cabinets, and drawers, should be labeled with signs that indicate the hazards of the chemicals stored within (i.e., flammable, corrosive, toxic, reproductive toxin, cancer-suspect agent, oxidizer).
- Ensure that all chemical containers are clearly labeled with the chemical name and appropriate hazard warnings. Chemical abbreviations, symbols, and structures should not be used as the sole means of communicating this information.
- Label glass containers with physical labels rather than writing on the glass so that the chemical can be identified if the bottle is broken.
- Never store chemicals at desks or in offices or other non-laboratory areas.
- Refrigerators used to store flammable liquids must be Underwriters-approved for flammable storage by the manufacturer – these refrigerators are designed not to spark inside.
- Do not store glass containers of chemical liquids on the floor.

Chemicals or other hazardous materials should not be stored within 18 inches of the edge of bench tops.

Working with particularly hazardous substances

- Working with particularly hazardous substances (allergens, embryotoxins, reproductive toxins, select carcinogens, substances with a high degree of acute toxicity or a moderate or high degree of chronic toxicity) requires special precautions, procedures, and training. Consult the Chemical Hygiene Plan and if necessary discuss with the Chemical Hygiene Officer/VEHS prior to conducting work with these materials.

Emergency Response Procedures

- Only clean up small chemical spills with no inhalation hazard for which you are comfortable with and have the appropriate clean up equipment and personal protective equipment.
- For spills that the lab personnel cannot clean up, evacuate and secure the area and notify VUPD immediately. Spill emergencies can be reported by dialing 911.
- Maintain spill kits in the lab suitable for spills that the lab intends to clean up and ensure that lab personnel are properly trained on their use.
- Dispose of used chemical spill clean up material as chemical waste through VEHS.
- Seek medical attention for all chemical exposures and when warranted by workplace injuries or illnesses.
- For non-life threatening chemical exposures, visit the Occupational Health Clinic (for employees of Vanderbilt) or Student Health Services (for students at Vanderbilt) during normal working hours. For emergencies or after hours incidents, visit the Vanderbilt Emergency Department at VUMC.
- Never send someone to a medical facility alone that is suffering from a chemical exposure. Always have them escorted and bring the appropriate material safety data sheet for the chemical involved.
- For chemical splashes into the eye, immediately flush the eye in an eye wash station for at least 15 minutes. Hold the eyelids away from the eyeball and move the eye up and down and sideways to wash thoroughly under the eyelids. Seek medical attention as soon as possible.
- For ingestion of chemicals, refer to the chemical's material safety data sheet for immediate treatment procedures and seek medical attention promptly.
- For chemical exposure to the body, remove contaminated clothing and flush with water in the emergency shower for at least 15 minutes.
- Only attempt to fight a fire if you are trained and qualified, have the appropriate fire extinguisher, and are confident that you will be successful.
- The fire extinguishers provided in the labs are appropriate for all fires except those involving metals such as sodium or magnesium. Class D fire extinguishers should be used for metal fires.
- To use a fire extinguisher, pull the pin, aim at the base of the fire, squeeze the handle, and sweep back and forth. Always start from 8 to 10 feet away and move in closer to avoid spreading the fire from the force of the extinguisher spray.
- In the event a fire cannot be extinguished, evacuate the building in accordance with the Department Emergency Response Plan for the Chemistry Department

(***link on Chemistry website to be added***). Rescue and remove other occupants only if you can do so without endangering yourself. Pull the fire alarm if necessary. Close doors and lower hood sashes if you can do so safely. Use stairs and stay low in smoky areas.

- If the fire alarm is sounding, all occupants must evacuate the building according to the Department Emergency Response Plan for the Chemistry Department. Assist and instruct visitors. Do not assume it is a false alarm.

Chemical Waste Disposal

Training

- Every laboratory that generates chemical waste must have a hard copy of the "Laboratory Guide for Managing Chemical Waste" provided by VEHS.
- Every laboratory that generates chemical waste must have a "Hazardous Chemical Waste Management Area" sign (provided by VEHS) posted near their chemical waste storage location or in another conspicuous location in the lab.
- Laboratory staff that has to handle chemical waste must be trained in proper chemical waste management procedures.

Storage

- Every laboratory that generates chemical waste must have at least one area designated for chemical waste storage that is known by lab staff handling chemical waste.
- Store chemical waste in containers that are compatible with the chemicals and that are in good condition and free of leaks or chemical residue.
- Store all chemical waste containers that hold liquid chemical wastes in secondary containment so that spills cannot reach sink or floor drains or containers of incompatible chemicals. The secondary containment should be adequate to hold the entire contents of the largest container stored. Contact VEHS (322-2057) to obtain secondary containment equipment.
- Segregate chemical wastes by compatibility, and never store incompatible wastes in the same secondary containment.
- Store halogenated solvents in separate containers from non-halogenated solvents.
- Store chemical wastes in the same laboratory where they are generated such that the wastes do not have to be transported through offices, hallways, corridors or other public areas for storage.
- Never store more than 55 gallons of waste in one storage location.

Labeling

- Label chemical waste containers with waste tags provided by VEHS as soon as waste accumulation begins even if more waste will be added later. There should never be a chemical waste container in your lab that has waste in it and that is not labeled with a VEHS waste tag.

Closed Containers

- Keep chemical waste containers closed at all times except to temporarily add more waste. This means no open funnels are allowed unless you are actively pouring waste into the container.
- Chemical waste containers must be closed with a screw-type lid or a screw-on funnel equipped with a lid that snaps close and has a latch to prevent it from opening accidentally.

Spills

- Clean up chemical waste spills immediately. There should be no chemical waste residue on chemical waste containers or in secondary containment tubs.

Disposal

- Submit an online chemical waste collection request form to VEHS when your chemical waste is ready for pickup -- www.safety.vanderbilt.edu/resources/hazard_collection.htm.
- Never pour chemical wastes down sink or other drains unless it is approved by the "Laboratory Guide for Managing Chemical Wastes" or VEHS.
- Never evaporate chemicals in the fume hood as a method of disposal.

Compressed Gases

Labeling & Storage

- Compressed gas cylinders should be labeled as to their contents. Note that the manufacturer label may not be adequate to describe the contents of the cylinder.
- Store cylinders so that their content labels are clearly visible.
- Store all cylinders in a dry, well ventilated area away from extreme temperature changes, sources of ignition or heat, moisture, and mechanical shock.
- Keep incompatible classes of gases stored separately. Keep flammables from reactives, which include oxidizers and corrosives. Gas cylinders of fuels (hydrogen, etc.) must be separated from gas cylinders of oxidizers (oxygen, etc.) by at least 20 feet or by a wall with a minimum fire rating of 2 hours.
- Always make sure that cylinders are secured to a permanent structural support and secured with a chain or a strap at two thirds of their height from the floor.
- For small cylinders or lecture bottles, utilize a stand or other appropriate mechanism to secure the cylinder to a stable surface.
- Segregate gas cylinder storage from the storage of other chemicals as much as possible.
- Cylinders ***that are in use*** must be secured individually so that no slippage or sliding occurs that could damage or alter the regulator.
- If cylinders must be ganged together for storage, only gang two cylinders together at a time, if possible.
- Cylinder carts are not a safe way of securing uncapped gases, even "only for a short time."
- Segregate empty cylinders from full cylinders and clearly mark the empty cylinders.

Usage

- Only Compressed Gas Association (CGA) standard combination of valves and fittings can be used in compressed gas installations.
- Gas lines and manifolds should be clearly marked with the identity of their contents and the direction of gas flow.
- When cylinders are no longer in use, shut the valves, relieve the pressure in the regulators, remove the regulators, and cap the cylinders.
- Make sure regulators are compatible with the gases they are being used with. Corrosive gases and carbon dioxide typically require regulators made of corrosive-resistant materials.
- Pressure regulators should be equipped with spring-loaded pressure relief valves to protect the low-pressure side. When used on cylinders of flammable, toxic, or otherwise hazardous gases, the relief valve should be vented to a hood or other safe location.
- Regulators used for corrosive gases should be removed immediately after use and flushed with dry air or nitrogen.
- Cylinder discharge lines should be equipped with approved check valves to prevent inadvertent contamination of cylinders that are connected to a closed system where the possibility of flow reversal exists.
- For small cylinders or lecture bottles, utilize a stand or other appropriate mechanism to secure the cylinder to a stable surface.

Transportation

- Always transport gas cylinders on wheeled cylinder carts with retaining straps or chains.
- Always transport lecture cylinders individually or in an approved carrier for transporting multiple cylinders.

Potential Leaks

- Only trained and designated persons may change or hook up gas cylinders.
- The laboratory faculty member must review and approve any new gas cylinder installation.
- Gas cylinders, hoses, tubing, and regulators must be maintained in good condition and replaced immediately if they become damaged or worn.
- Do not lubricate gas cylinder fittings and do not force tight fits.
- Open valves slowly, and do not stand directly in front of the gauges in case the gauge face blows out.
- Corrosive, toxic, and flammable gases must be connected with one continuous tube from the regulator to the apparatus.
- Cylinders, connections, and hoses should be checked regularly for leaks using an appropriate gas detector (if applicable), soapy water, or a 50 percent glycerin-water solution, can be used to look for bubbles.
- When the gas to be used in a procedure is a flammable, oxidizing, or highly toxic gas, the system should first be checked for leaks using an inert gas before introducing the hazardous gas.

- Laboratory personnel should never attempt to repair a leak at the junction of the cylinder valve and the cylinder or at the safety device. Contact the manufacturer or supplier for assistance.
- If a leak at the cylinder valve handle cannot be remedied by tightening a valve gland or a packing nut, contact the manufacturer or supplier for assistance.
- Use of internal bleed-type regulators should be avoided.

Empty Cylinder Disposal

- Whenever possible, only purchase cylinders (including lecture cylinders) that can be returned to the distributor.
- If cylinders cannot be returned to the distributor (including lecture cylinders), contact VEHS for proper disposal.

Special Requirements for Highly Toxic Gases

Examples of highly toxic gases include Bromine, Nitric oxide, Chlorine and Hydrogen Chloride.

- Contact the Chemical Hygiene Officer/VEHS to review plans for using highly toxic gases to ensure adequate safety measures are in place.
- Cylinders of highly toxic gases must be stored in a fume hood or a ventilated containment cabinet designed for storage of such gases.
- Gases should be mixed in the exhaust hood or cabinet to reduce concentrations in lines passing through occupied room space.
- Compatible metal tubing/piping without joints should be used to transport the gases across room space.
- Supply lines should be enclosed in an exhaust line (line within a line) connected to the exhaust system to capture, contain, and ventilate any leaks.
- An automatic shutoff should be used to turnoff gas supply in the event of a sudden loss of pressure in the supply line.
- A critical orifice should be used when possible to prevent free flow into the supply line.
- An alarm system should be used to detect leaks for routinely used highly toxic gases, or those with no or poor warning properties. The alarm level should be set at the permissible exposure level (PEL – found on the material safety data sheet) for that gas or lower.
- Order cylinders only when ready for experiments (check availability of gas).
- Order and store the minimum quantities required to perform research work.
- Only allow persons directly involved in the laboratory work and that have been advised of the hazards, controls, alarms, and emergency procedures in laboratories where these gases are being stored or used.

Ensure that written procedures exist for checking for leaks in new cylinders and experimental setups, safely changing out gas cylinders, and responding to emergencies.

Lasers

- If you are working with lasers, review the laser safety information and training available online at the VEHS website: www.safety.vanderbilt.edu/resources/cls_laser.htm
- Never look directly at the beam or pump source.
- Always wear goggles that offer protection against the specific wavelength of the laser in use. Multiple goggles may be required if multiple wavelengths are used. No available goggles protect against all laser wavelengths.
- Never view the beam pattern directly. Use an image converter or other safe, indirect means. To decrease reflecting hazard, do not aim by looking along the beam.
- Do not allow any objects that cause reflections to be present in or along the beam. Even buttons on clothing and polished screw heads can be dangerous.
- Keep a high general illumination level in areas where lasers are in operation. Low light levels cause dilation of the pupils and increase the risk of injury.
- Display appropriate warning signs in laser areas.
- Always terminate the laser beam with a light absorbing material or diffuse screen.
- Clearly mark the path of the beam and provide barriers to prevent accidental contact with eyes (for all lasers) and other body parts (for high power lasers).
- Provide an emergency shutdown or "kill" switch in an accessible location away from the laser.

Refrigerators and Freezers

- Avoid storing highly toxic or explosive chemicals in refrigerators. If these materials must be stored in a refrigerator, minimize the quantity and clearly label the refrigerator with appropriate warning signs.
- Never place uncapped chemical containers in a refrigerator. Screw-caps should be used. Avoid the use of aluminum foil, plastic wrap, corks, and glass stoppers as capping devices.
- Do not use water-soluble ink to label chemical containers stored in a refrigerator. Use water-proof labels or cover labels with transparent tape.
- Be extra cautious in ensuring proper segregation of incompatible chemicals in refrigerators and freezers.
- Maintain an inventory of each refrigerator and freezer.

Centrifuges

- Centrifuges must be properly installed and operated in accordance with the manufacturer's specifications.
- Centrifuges must be operated by trained and qualified lab personnel.
- The load must be balanced and the lid closed each time the centrifuge is operated.
- The operator must not leave the centrifuge until the full operating speed is achieved and the centrifuge appears to operating normally with no vibration.
- If vibration occurs, stop the run immediately, wait until the rotor stops, and check the load balance.
- Do not lean on or place items on the centrifuge while it is running.

- For use with flammable and/or hazardous materials, the samples should be contained in safety cups, sealed tubes, or safety rotors, and the centrifuge should be under a negative pressure and vented to an appropriate local exhaust system.

Stirring and mixing devices

- Follow manufacturer's instructions.
- Use only spark-free induction motors.
- Ensure that these devices are plugged into a receptacle outside the fume hood and that they can be turned on or off by a switch located outside the hood in the event of an emergency.

Ovens

- Follow manufacturer's instructions.
- Volatile hazardous materials should not be dried in an oven unless the oven has continuous ventilation of the atmosphere inside the oven to an appropriate local exhaust system.
- Bimetallic strip thermometers are preferred for monitoring oven temperatures. Mercury thermometers should not be mounted on the tops of ovens such that the bulb hangs into the oven.
- Explosion proof ovens with rear blowout panels should be used for volatile materials.

Hot Plates

- Follow manufacturer's instructions.
- Containers to be heated on hot plates should be no larger than the dimensions of the hot plate.
- Appropriate quality glass should be used for hot plate heating.
- Inspect all glassware for surface flaws or imperfections prior to use with hot plates.
- Flammable liquids should not be heated with hot plates that are not rated for flammables.
- Do not use ceramic top hot plates if they are scratched because they may shatter upon heating.

Heating Mantles

- Follow manufacturer's instructions.
- Always use heating mantles with a variable autotransformer to control the input voltage.
- Correctly match the mantle size with the vessel bottom shape and size.

Oil Immersion Heating Baths

- Follow manufacturer's instructions.
- Oil baths must be monitored with a thermal sensing device to ensure its temperature does not exceed the flash point of the oil being used. Oil baths left

unattended must be equipped with an automatic shutoff device connected to the thermal sensor to prevent overheating.
- Hot oil circulators require the use of securely attached high temperature tubing, preferably flexible stainless steel with an inert liner.
- Oil type and quality should be reviewed periodically.
- Discard old oil baths after discoloration begins to occur or after several uses at high temperatures.

Water Baths
- Water baths must be checked for pitting, rusting, holes, and proper water level prior to use.
- The bath line should match the vessel solution line.
- For heating flammable liquids, monitor the temperature of the bath frequently. Since solvent polarity is likely to be different from that of water, special attention must be given to the proper rheostat setting for bath temperature.

Vacuum Pumps
- If possible, use a facility vacuum system, water aspirator, or steam aspirator (each system protected by a suitable trapping device) for distillation or concentration operations involving significant quantities of volatile substances rather than using a mechanical vacuum pump.
- Suction lines from the system to the vacuum pump should be fitted with a cold trap to collect volatile substances from the system and to minimize the amount of material that enters the vacuum pump and dissolves in the pump oil.
- Output of vacuum pumps used to evacuate a system containing volatile toxic, corrosive, or flammable substances should be vented to an appropriate local exhaust system and passed through a scrubber or absorber device, if necessary.
- Drain and replace pump oil that has become contaminated. Dispose of all waste pump oil through VEHS.

Electrical Equipment
- Electric power receptacles for operations conducted in hoods must be located outside the hood. The cord should be routed under the air foil, if possible, so that the hood sash can be completely closed.
- Only trained and qualified personnel should perform repair or calibration work on electrical equipment.
- All appliances must have three-prong, grounded plugs, and all receptacles must be able to accept a three-prong plug and provide a ground connection. The receptacle should be oriented such that the ground wire is on top to protect the hot and neutral line from falling objects.
- Extension cords should only be used for temporary operations (less than one day). Standard three-conductor extension cords with sufficient rating for the equipment with an independent ground connection must be used.
- Equipment that is likely to be left running unattended (variable autotransformers, vacuum pumps, drying ovens, stirring motors, etc.) should be equipped with a

fuse or other overload protection to disconnect the circuit if the equipment fails or is overloaded.

- Ensure all electric cords are in good condition and not frayed.
- Label defective electrical items to prevent their use while waiting for repair.
- Locate electrical equipment so as to minimize the possibility of spills into the equipment or flammable vapors carried into it.
- Turn off appliances before removing plugs from outlets to prevent voltage surges when the plug is reinserted.
- Minimize the condensation that may enter electrical equipment placed in a cold room or large refrigerator. Mount the equipment to the wall or vertical panel, if possible.

Motor driven electrical equipment (vacuum pumps, mechanical shakers, stirring devices, and rotary evaporators) used with flammable materials or in areas where volatile flammable materials are present should be equipped with non-sparking induction motors or air motors instead of series-wound motors that use carbon brushes. The induction motors should meet Class 1, Division 2, Group C-D electrical standards.

APPENDIX F

DEFINITIONS

DEFINITIONS

Action Level means a concentration designated in 29 CFR part 1910 for a specific substance, calculated as an 8-hour time weighted average (TWA), which initiates certain required activities such as exposure monitoring and medical surveillance.

Chemical Hygiene Officer means an employee who is designated by the employer, and who is qualified by training or experience to provide technical guidance in the development and implementation of the provisions of the Chemical Hygiene Plan (CHP).

Combustible Liquid means any liquid having a flashpoint at or above 100°F (37.8°C), but below 200°F (93.3°C), except any mixture having components with flashpoints of 200°F, or higher, the total volume of which make up 99% or more of the total volume of the mixture.

Compressed Gas means:

- A gas or mixture of gases having, in a container, an absolute pressure exceeding 40 pounds per square inch (psi) at 70°F (21.1°C), or
- A gas or mixture of gases having, in a closed container, an absolute pressure exceeding 104 psi at 130°F (54.4°C) regardless of the pressure at 70EF, or
- A liquid having a vapor pressure exceeding 40 psi at 100°F (37.8°C) determined by ASTM method D-323-72.

Designated Area means an area which may be used for work with select carcinogens, reproductive toxins or substances which have a high degree of acute toxicity. A designated area may be the entire laboratory, an area of the laboratory or a device such as a laboratory hood.

Emergency means any occurrence such as, but not limited to, equipment failure, rupture of containers or failure of control equipment which results in an uncontrolled release of a hazardous chemical into the workplace.

Employee means an individual employed in a laboratory workplace who may be exposed to hazardous chemicals in the course of his or her assignments. At VU employees include staff members, graduate research assistants and teaching assistants and administrative support staff who work in laboratory areas. Students at VU are not considered employees.

Explosive means a chemical that causes a sudden, almost instantaneous release of pressure, gas, and heat when subjected to sudden shock, pressure, or high temperature.

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

Aerosol Flammable means an aerosol that, when tested by the method listed in 16 CFR 1500.45, yields a flame protection exceeding 18 inches at full valve opening, or a flashback at any degree of valve opening.

Gas Flammable means:

- A gas that, at ambient temperature and pressure, forms a flammable mixture with air at a concentration of 13% by volume or less, or
- A gas that, at ambient temperature and pressure, forms a range of flammable mixtures with air wider than 12% by volume, regardless of the lower limit.

Liquid Flammable means any liquid having a flashpoint below 100°F (37.8°C), except any mixture having components with flashpoints of 100°F or higher, the total of which make up 99% or more of the total volume of the mixture.

Solid Flammable means a solid, other than a blasting agent or explosive, that is liable to cause fire through friction, absorption of moisture, spontaneous chemical change, or retained heat from manufacturing or processing, or which can be ignited readily and when ignited burns so vigorously and persistently as to create a serious hazard. A chemical shall be considered to be a flammable solid when tested by the method described in 16 CFR 1500.44, it ignites and burns with a self-sustained flame at a rate greater than one-tenth of an inch per second along its major axis.

Flashpoint means the minimum temperature at which a liquid gives off a vapor in sufficient concentration to ignite when tested by the Tagliabue Closed Tester, Pensky-Martens Closed Tester, or Setaflash Closed Tester using the appropriate American National Standard Method of Test. Organic peroxides, which undergo autoaccelerating thermal decomposition, are excluded from the flashpoint determinations listed above.

Hazardous Chemical means a chemical for which there is statistically significant evidence that acute or chronic health effects may occur in exposed employees. The term health hazard includes chemicals that are carcinogens, toxic or highly toxic agents, reproductive toxins, irritants, corrosives, sensitizers, hepatotoxins, and nephrotoxins.

Highly toxic means a chemical falling within any of the following categories:

- 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.

Laboratory means a facility where the "laboratory use" of hazardous chemicals occurs. It is a workplace where relatively small quantities of hazardous chemicals are used on a non-production basis.

Laboratory Scale means work with substances in which the containers used for reactions, transfers, and other handling of substances are designed to be easily and safely manipulated by one person.

Laboratory Hood means a device located in a laboratory, enclosed on five sides with a movable sash or fixed partial enclosure on the remaining side; constructed and maintained to draw air from the laboratory and to prevent or minimize the escape of air contaminants into the laboratory; and allows chemical manipulations to be conducted in the enclosure without insertion of any portion of the body into the hood other than the hands and arms.
Walk-in hoods with adjustable sashes meet the definition provided that the sashes are adjusted during use so that the airflow and the exhaust of air contaminants are not compromised and employees do not work inside the enclosure during the release of airborne hazardous chemicals.

Laboratory use of hazardous chemicals means handling or using hazardous chemicals in which all of the following conditions are met:

- Chemical manipulations are carried out on a "laboratory scale".
- Multiple chemical procedures or chemicals are used,
- The procedures involved are not part of a production process, nor in any way simulate a production process, and
- Protective laboratory practices and equipment are available and in common use.

Organic peroxide means an organic compound which contains the bivalent -O-O- structure and which may be considered to be a structural derivative of hydrogen peroxide where one or both of the hydrogen atoms have been replaced by an organic radical.

Oxidizer means a chemical other than a blasting agent or explosive that initiates or promotes combustion in other materials, thereby causing fire either of itself or through the release of oxygen or other gases.

Physical hazard means a chemical for which there is scientifically valid evidence that it is a combustible liquid, a compressed gas, explosive, flammable, an organic peroxide, an oxidizer, pyrophoric, unstable (reactive), or water-reactive.

Reproductive toxin means chemicals which affect the reproductive capabilities including chromosomal damage (mutations) and effects on fetuses (teratogenesis).

Select carcinogen means any substance which meets the following criteria:

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

Toxic means a chemical falling within any of the following categories:

- 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.
- 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 two and three kilograms each.
- 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 two milligrams per liter but not more than 20 milligrams per liter of mist, fume, or dust, when administered by continuous inhalation for one hour (or less if death occurs within one hour) to albino rats weighing between 200 and 300 grams each.

Unstable (reactive) means a chemical which in the pure state, or as produced or transported, will vigorously polymerize, decompose, condense, or will become self-reactive under conditions of shock, pressure or temperature.

Water-reactive means a chemical that reacts with water to release a gas that is either flammable or presents a health hazard.