This manual is thought to be complete at the time of its writing and to accurately represent the operational policies of the Department of Physics and Astronomy and the potential hazards involved in using various department facilities. Comments and suggestions regarding the contents of this manual should be directed to:

Physics Safety Committee
Professor Anthony B. Hmelo (Chair)
Revision 5.0: January 8, 2007
This Physics Safety Plan has been edited and reviewed by the Physics Safety Committee:

- Chair: Professor Anthony Hmelo (VINSE)
- Professor A. V Ramayya
- Professor Will Johns
- Mr. Ron Reiserer (VIIJRE)
- Professor Ken Schriver
- Professor Vicki Greene (DGS), ex officio
- Ms. Sandy Childress, ex officio

These seven individuals comprise the core of the Physics Safety Committee. In addition, other attendees include:

- Professor Robert Scherrer, (Department Chair)
- Other invited attendees, including VEHS representation, depending on the agenda.

Committee Charge

The Physics Safety Committee is charged to promote increased safety in the Physics Departmental research operations at Vanderbilt University. This committee meets to review equipment installations and procedures and recommend changes to the standard operating procedures of the various laboratories.

The Physics Safety Committee meets at least once per semester to monitor compliance with the safety guidelines set forth in this document, including safety training compliance. In addition, the committee meets on an ad hoc basis at the request of the committee chair or department chair in response to safety-related incidents as required.

This Physics Safety Plan is deemed applicable to all departmental laboratories located in the Stevenson Science Center Building 6. Important departmental facilities not subject to this plan include the Free Electron Laser Facility, the Astronomical Observatories, and the Science Machine Shop, which are subject to their individually tailored safety plans.
Executive Summary

This Physics Safety Plan is deemed applicable to all departmental laboratories located in the Stevenson Science Center Building 6. Important departmental facilities not subject to this plan include the Free Electron Laser Facility, the Astronomical Observatories, and the Science Machine Shop, which are each subject to their individually tailored safety plans. Compliance with the Physics Safety Plan is monitored by the Physics Safety Committee and enforced by the Department Chair.

The Physics Safety Plan at a glance:

1) The Department of Physics and Astronomy promotes safety awareness through one-time VEHS sponsored general lab safety training for all Physics students and staff, including faculty.
   a. Laboratory-specific training as per individual lab hazards.
   b. Utilizing as many VEHS online and standup training resources as possible.

2) Every PI will develop and post a Standard Operating Procedure for their laboratories that meets or exceeds the standards set forth in the Physics Safety Plan.

3) Each PI will designate a lab safety compliance officer who manages the chemical inventory and wastes, the MSDS library for that lab, as well as door security.

4) Institute a Buddy system for after-hours and weekend lab access.

5) Each lab to have a general first aid kit. Specialized kits required in labs with special hazards ... ie acid burn.

6) Each lab to have a chemical spill kit.

7) Each floor to have a defibrillator.

8) Physics Safety Committee will organize annual pre-emptive inspections to drive 100% compliance with the annual VEHS Chemical Waste Audit.

9) The plan includes reference sections for chemical, laser, radiation, bio safety information, including VEHS waste disposal guidelines.
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1.0 Introduction to the Physics Department Laboratory Safety Plan

Welcome to the Physics department laboratories. Admittance to these facilities is a privilege and not a right. Safety is the most important aspect of using the labs. You, as a user, must do everything possible to ensure your own safety, as well as the safety of those around you. This manual will provide the basic safety rules and guidelines that will help ensure that your work in the department laboratories is as productive and as safe as possible. The Physics Department strives to provide a safe working environment for all university students and employees.

The Physics Safety Committee (PSC) has recommended a variety of measures to ensure that the laboratory provides a clean and safe working environment. It is the responsibility of all users and staff to act in a professional, courteous and safe manner at all times while in Physics departmental facilities. Adherence to these safety recommendations will reduce laboratory accidents, spills and fires and promote a safe and healthful workplace for all Physics researchers.

Physics laboratory users violating the operating and safety rules of the department or endangering the safety of themselves or other users may be denied further access to the departmental laboratories at the sole discretion of the Department Chair upon the recommendation of the Physics Safety Committee.

1.1 Safety in the Physics Department Laboratories (Overview)

Welcome to the Physics Department Laboratories. Admittance to these facilities is a privilege and not a right. Safety is the most important aspect of using the labs. You, as a user, must do everything possible to ensure your own safety, as well as the safety of those around you. This manual will provide the basic safety rules and guidelines that will help ensure that your work in the department laboratories is as productive and as safe as possible.

Safety is an overriding concern in all department laboratory activities. All operations must be undertaken with the safety of both the individual user and other users as the primary consideration. In fact, operating safely is more important than getting your project or experiment completed. As a general rule, anyone who violates any safety rule or otherwise compromises his or her personal safety or the safety of others will be denied access to the department laboratories. These suspensions will be determined by the Physics Safety Committee in consultation with the user’s supervisor and the Department chair, and may include permanent suspension. Ignorance of the rules, fatigue, language difficulties, carelessness, and haste are not acceptable excuses for unsafe behavior. For graduate students, violations could mean the end of your thesis research. For outside users, violations could mean the end of your project in the department laboratories. Our policy is that users will be formally warned on the first minor infraction. A suspension is imposed upon the second minor infraction. Major infractions will result in immediate suspension of department laboratory access privileges. Readmission to the laboratories
will be at the sole discretion of the Physics Safety Committee, in consultation with the user's supervisor.

We wish to keep the laboratory an informal and friendly place to work for all researchers. The Department wishes neither to make nor to enforce unnecessary or burdensome rules. For the most part, rules on chemical use are formulated on the basis of chemical knowledge from Material Safety Data Sheets (MSDS), the properties of individual chemicals, and common sense. In many cases, rules and procedures have been created in response to specific incidents of chemical misuse by users in other campus labs. In addition, a significant number of state and federal regulations cover safe chemical use in the workplace and the proper disposal of hazardous waste materials. In addition to policies, procedures and protocols, the primary responsibility for safety in the departmental laboratories rests with the individual researcher. A responsible and considerate lab user with an understanding of basic chemistry and common sense will have little difficulty in following the departmental rules for using chemicals and other hazardous entities in the departmental laboratories in a safe, and environmentally sound fashion.

Research lab experience has shown that a majority of problems, safety violations, and equipment damage in these labs are the result of haste. Graduate students are under a lot of pressure to get their work done. There is only so much time and many tasks to be accomplished. However, you can waste your samples, waste time and money, get poor results, break things, and endanger yourself and others by being careless. Carelessness in departmental laboratories simply will not be tolerated.

Your safety in the laboratory is determined not only by your actions but also by the actions of those around you. Since supervisory personnel may be in the laboratory only a fraction of the time the lab is open, the users are often in the best position to observe the behavior of themselves and others. Thus, if you observe someone else in the lab working in an unsafe manner, it is your first responsibility to bring this observation to his or her attention, and then if necessary, bring it to the attention of the laboratory manager, laboratory director, or a faculty member. The access of everyone to the laboratories depends on maintaining a safe working environment. A series of thoughtless violations or a single serious personal injury could result in closing of a laboratory for weeks. We hope that peer pressure will result in conformance to safety standards where direct staff observation is not possible.

Potential dangers exist in many forms. For example, many laboratories are filled with sophisticated process equipment employing chemicals that are dangerous on several levels either by themselves or in combination with other materials. Also, compressed gases and hazardous voltages are used in many research tools in the labs. Potential hazards in department labs fall into several categories:

* Chemicals;
* Toxic, Corrosive, Oxidizing, Pyrophoric and Flammable Gases;
• Thermal energy from hot plates or ovens;
• Tissue damage from cryogenic liquids at very low temperatures;
• Electrical energy that can cause shocks or burns;
• Pneumatic and Hydraulic energy;
• Ionizing and Non-ionizing radiation sources;
• Labs;
• Mechanical energy from moving parts; and
• Sharp edges

The following general guidelines form the foundation of the Physics Safety Plan. These practices are deemed to be applicable to all departmental laboratories. However, each lab may establish operating local procedures that exceed these requirements in response to specific hazards present in that lab.

1.2 Laboratory Management

Each Departmental research lab is subject to the direct supervision of a faculty member who is the Principle Investigator for that lab. The principle investigator shall designate an individual of his choice to be the safety compliance officer for that lab who shall be responsible for the day-to-day operation of the lab. This individual may be a graduate student, post doc, research faculty or other staff member at the discretion of the principle investigator. The safety compliance officer shall be responsible to insure that all applicable VEHS procedures for chemical storage and handling are enforced, that safe waste management practices are observed, that the MSDS file for all chemical usage in the laboratory is maintained, and is responsible for door security. The safety compliance officer and the principle investigator together will insure that all individuals working in the lab have received basic safety training and specific training required for the operation of specialized equipment and processes.

1.2.1 Individual Laboratory Safety Plan:

The Department recognizes that each laboratory present specialized hazards in addition to safety concerns of a more general nature. In addition to overall safety considerations presented in this document, the Department requires that each of laboratory PI author a detailed lab safety and security plan which addresses concerns of chemical waste management, laboratory safety training, record keeping, laboratory access policy, and buddy system compliance. The individual laboratory safety plan shall be filed with the Physics Safety Committee for reference and audit purposes.

Each laboratory will provide access to comprehensive operations manuals for all equipment used in the lab. Each laboratory will maintain a comprehensive hardcopy MSDS file for all chemical materials in use in that laboratory.

1.2.2 Hours of Operation
Most laboratories are in operation 24 hours a day 7 days a week, subject to the policies of the principle investigator. Generally speaking, prudent laboratory safety considerations require that laboratory doors be locked when unoccupied to prevent the lost and the curious from either injuring themselves or others. This implies that each laboratory should implement individual tailored policies for determining when a lab door should be locked. For example, after hours access during evening, nights and weekends should be by key to insure that doors remain locked when the lab is unoccupied.

1.2.2.1 Laboratory Door Security

The principle investigator is responsible for the safe operation of the lab. In the interest of promoting safety and avoiding theft, mishap, vandalism and unintended consequences lab users are required to closed and lock the laboratory door when the lab is unoccupied. The safety compliance officer for each lab shall have the ultimate responsibility to insure that doors are closed and locked during evenings, weekends and holidays.

1.2.3 Buddy Requirement for afterhours laboratory access:

Prudence suggests that a laboratory buddy system affords the best response to unexpected laboratory accident and security concerns. The laboratory buddy becomes the first responder in the event of accident or other laboratory incident. The Physics Department requires that each individual lab establish policy for how a buddy system is implemented in their lab as part of each laboratory’s safety plan. Lab users shall work in groups of 2 or more during evenings, weekends and holidays to insure that assistance is available in the event of a laboratory emergency.

1.2.4 Visitors and Guests

All departmental employees are responsible for the actions and safety of our guests when touring the laboratories. The principle investigator shall determine whether a laboratory guest must be escorted or supervised in the lab.

1.2.5 Chemical Spill Kit

Each laboratory that uses chemical reagents shall provide a spill kit for containing and cleanup of chemical spills that may occur in the lab.

1.2.4 First Aid Kit

Each lab shall provide and maintain a first aid kit appropriate to the hazards present in the specific lab. For example, a lab that uses HF acid shall provide a HF burn first aid kit.

1.2.7 Defibrillator
The Department shall make a defibrillator available on every floor of Stevenson Building 6. The Physics Safety Committee shall designate one individual on each floor to be trained in the proper use of the defibrillator.

1.2.5 Hazard Communication

Faculty members must ensure that lab workers have access to hazard information for all hazardous materials 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 will be provided on the Department website.)
- The location and availability of this Physics Safety 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 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.

1.2.8.1 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.

1.2.8.2 Manufacturer's Labels

Incoming chemicals must not have their labels removed or defaced.

1.2.8.3 Lab Hazard Signs

The Vanderbilt Environmental Health and Safety Department (VEHS) posts Lab Hazard Signs on entranceways 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 entrancesways 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.

1.2.8.4 Chemical Inventories

Labs must maintain an inventory of all hazardous chemicals used and stored in the labs. This inventory must include the following at a minimum:

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

1.2.8.5 Chemicals Developed in the Laboratory

For chemicals developed in the laboratory for the exclusive use of the laboratory, if the composition of the chemical substance is known, the faculty member must determine if it is a hazardous chemical. If the chemical is determined to be hazardous, the faculty member must provide information on the hazards of the chemical and appropriate training in accordance with this Physics Safety Plan.

If the chemical produced is a byproduct whose composition is not known, the faculty member must assume it is hazardous and must provide information on the hazards of the chemical and appropriate training in accordance with this Physics Safety 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.

1.2.8.6 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.
• Inventories of hazardous chemicals used and stored in the lab must be maintained including the chemical name, physical state, quantity, and general location.

• Chemicals developed in the lab must be evaluated to determine if they are hazardous. If they are hazardous or a hazardous determination cannot be made, they must be addressed in accordance with this Physics Safety 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.

1.3 General Departmental Laboratory Safety Training Policy

The Physics Safety Plan intends to minimize hazards and preempt accidents through a program of training and oversight. The Physics Safety Committee has recommended that the Department utilize available VEHS training resources such as VandySafe Modules and stand-up training by VEHS safety officers, as are applicable to department needs. All departmental students and staff shall receive basic lab safety training. Additional training may be required to operate specialized equipment in laboratories where known hazards exist. For example, laser users shall be required to complete laser safety training, accelerator users shall be required complete radiation safety training, and so on. Each principle investigator shall establish a training program and written procedures for the operation of specialized equipment in departmental laboratories.

The Department requires that all incoming graduate students undergo basic laboratory safety training upon their enrollment in the Department at the beginning of either the Fall or Spring semester as appropriate. Upon completion of such training VEHS will award the enrollee a completion certificate in electronic form that may be filed with the student’s advisor, laboratory supervision and Department as evidence of satisfying this requirement.

All Department employees have the opportunity to enter laboratory facilities from time to time, or may be impacted by laboratory operations elsewhere in the Building. Finally, the Department will formulate and announce a plan to train those faculty, staff and graduate students who joined the Department prior to August 2004 for the purpose of establishing a uniform minimum standard of training for safety awareness among all employees.

VEHS conducts monthly training entitled “Physical and Chemical Laboratory Safety,” that includes training on overall safety and prudent laboratory practices and chemical waste training. At the discretion of every Physics department employee’s supervisor that employee will either a) complete the monthly training in a classroom setting, or b) undergo web-based training for chemical waste and laboratory safety as developed by VEHS on their safety website

www.safety.vanderbilt.edu/training/topics_chemsafety.htm
In addition, each laboratory will assign addition specific training as appropriate to the hazards present in their areas, such as laser safety, accelerator training, cleanroom safety, and the like. Each physics department laboratory PI will formulate a safety policy and individual safety plan to be reviewed by the Physics Safety Committee and approved by the Department Chair.

The Department will establish a safety-training checklist tailored to the needs of every member of the Department that will include mandatory general training as well as those specialized training modules that are recommended by the member’s supervisor. This checklist will be filed in the Department office and will be reviewed as part of the department member’s annual performance review.

1.4 Annual Laboratory Inspections

The Department will perform announced preemptive annual laboratory inspections for the purpose of driving compliance with the annual VEHS waste audit, and to identify general laboratory concerns and recommend specific actions to address these concerns. These inspections shall be conducted within a period of 30 days prior to the announced VEHS inspection date. The Physics Safety Committee will establish a subcommittee for the purpose of conducting these inspections, and will report their findings to the full Committee, who will in turn report their recommendations to the Department Chair for action. See Appendices B, C, D and E.
2.0 ROLES AND RESPONSIBILITIES

Dean of the College of Arts and Sciences

- Provides management support for the Physics Department Safety Committee.
- 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 and the budget for its implementation and maintenance.
- 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.

Physics Department Chair

- Appoints members of the Physics Safety Committee.
- Appoints the Physics Safety Committee Chair and ensures that the Chair has the appropriate experience and training to perform the duties required by the plan.
- Supports University and departmental policies and training programs related to the use of appropriate environmental health and safety practices and facilities in research and teaching activities in the Physics Department.
- Ensures that good safety practices and environmental compliance are enforced within the Physics Department.
- Supports and establishes the authority of the Physics Safety Committee to carry out their duties and to function effectively within the department.
- Reports non-compliance and unsafe working conditions to the Vanderbilt Compliance Office.

Physics Safety Committee

- Recommends to the administration the health and safety policies and procedures for the facility to prevent losses due to accidental injury or occupational illnesses.
- Assures that all employees of the facility are aware of health and safety procedures and practices and are not exposed to an unhealthy or unsafe environment.
- Authorized to take immediate corrective actions in coordination with the Department Chair when conditions of imminent hazard to employees or students are found or damage to the Physics facility is possible.
- Consults with supervisors, administration, and employees regarding the health and safety aspects of their activities and environments.
- Has knowledge of institutional, local, state, and federal environmental health and safety policies applicable to the Physics Department.
- Maintains reference materials from local, state, and federal agencies with regard to rules and regulations affecting facility operations and interprets these rules and
regulations for inclusion in safety guidelines and posts appropriate reference material on
the Physics website.
• Develops and maintains the Physics Safety Plan. This includes an annual review and
approval of the Physics Safety Plan. Ensures that the Physics Safety Plan is being
implemented in all Physics Department laboratories.
• Ensures that the Physics Safety Plan meets the requirements of TOSHA’s Laboratory
Standard.
• Ensures that students, faculty and staff receive adequate training on the applicable
portions of the Physics Safety Plan.
• Establishes and maintains a safety training program for faculty, staff, and students.
• Manages the laboratory audit program. This includes establishing the audit procedure,
reviewing audit results, reporting the results to the Chair and the Dean of Arts and
Sciences, and addressing compliance issues.
• Investigates accidents and conditions which may produce injury and illness in order to
identify causes and develop preventive measures.
• Compiles data concerning incidence of work-related injury and illness for risk-control
purposes.
• Serves as a consultative body to administrators, supervisors, and employees concerned
with matters of health and safety.
• Ensures that life safety systems including fire-extinguishing equipment, fire alarm
systems, engineering controls (fume hoods, ventilation systems design and function,
chemical and flammable storage, etc.), and personal protective equipment are inspected
and maintained in accordance with manufacturers’ recommendations or industry
standards.
• Committee membership shall always include representatives from VINSPI, VIIBRE,
and other large laboratories as they are established.

Physics Safety Committee Chair

• Provides technical guidance in the development and implementation of the provisions
of the Physics Safety Plan.
• Manages and coordinates all activities of the Physics Safety Committee.

Principal Investigators (PI's)

• Has knowledge of institutional, local, state, and federal environmental health and safety
policies applicable to the research being performed.
• Ensures that safety, health and compliance issues are properly addressed in their labs or
for those experiments being done under their supervision.
• Participates in laboratory safety training as required.
• Ensures that all employees and students working in a laboratory under their supervision
have received general chemical safety training.
• Provides all employees and students working in a laboratory under their supervision
with laboratory-specific and/or process-specific training and documents such training.
• Maintains a current inventory of all chemical compounds used in the laboratory.
• Follows the guidelines presented in the Physics Safety Plan and ensures that the Physics Safety Plan is implemented in their laboratories.
• Has knowledge of potential hazardous and/or regulated materials used in research and is trained in methods to minimize the risks of the hazards and to meet institutional compliance requirements.
• Seeks appropriate approvals/guidance through the Physics Safety Committee, the Vanderbilt Environmental Health and Safety Department (VEHS), and the department Chair for the use of potentially hazardous or regulated materials.
• Ensures that installation requirements of equipment, exhaust systems, etc., involving potentially hazardous or regulated materials are coordinated through the Vanderbilt Campus Planning and Construction Department, prior to requests for construction estimates.
• Develops laboratory-specific standard operating procedures that describe the safety and health considerations for the processes in their laboratories that involve the use of hazardous materials.
• Ensures the integrity of equipment and facilities designed to contain potential hazards by providing recommended maintenance and calibration.
• Facilitates internal and external inspections of research facilities and equipment.
• Takes prompt action when unsafe acts or conditions are reported or noted.
• Follows written emergency procedures.
• Reports all on-the-job accidents, illnesses, and/or potential exposures to the Vanderbilt Occupational Health Clinic or Student Health Services.
• Requests medical assistance as required and provides information regarding hazards involved to medical personnel.

Laboratory Staff and Students

• Participates in laboratory safety training and laboratory-specific or process-specific training as required.
• Reports to the laboratory in appropriate attire.
• Wears prescribed personal protective equipment.
• Follows safe practices in the laboratory and adheres to applicable portions of the Physics Safety Plan and laboratory-specific standard operating procedures.
• Reports safety concerns and/or problems to the PI or department Chair.
• Reports any work-related injury or illness to the supervisor and seeks prompt medical treatment, if necessary.
• Refrains from conducting any laboratory operation or operating any equipment without proper authorization or instruction.
3.0 Chemical Safety

**Short and Simple Chemical Safety Rules**

- Know the chemical you are using. Material Safety Data Sheets (MSDS) are available.
- Wear gloves and other required PPE when handling or working with any chemical.
- Any use of acids must be performed only at the Acid benches. For Hydrofluoric Acid you must use safety glasses, a full apron with sleeves, nitrile gloves, and a face shield.
- NEVER mix acids and solvents – this action can result in an explosion.
- NEVER add water to acid (NAW) – it can splatter violently.
- Always add acid to water (AAA).
- Perchloric acid is strictly prohibited in the Physics Department Laboratories.
- Hydrofluoric acid (HF) is commonly used in silicon processing. It is especially dangerous in that, with skin contact, there is no immediate symptom of pain, but severe damage to the bone can result over a few hours following an exposure. Take extreme care when using HF.
- Know where the nearest eyewash station is when you are working with chemicals. If a chemical gets in your eye, call for help and flush eyes for at least 15 minutes.
- Solvents are highly flammable. Keep them away from any ignition source.
- Wear safety glasses with sideshields, full apron with sleeves, nitrile gloves, and a face shield when pouring chemicals.
- Properly label all chemical containers: Name, Date, & Contents.
- Never leave chemicals unattended without identification.
- For reasons of contamination NEVER put any chemicals back into their original containers.
- Pour only the necessary amounts of chemicals you are planning to use.
- Proper chemical disposal is mandatory.
- All liquid and solid wastes must be put in the appropriate labeled container for pickup & disposal.
- Solvents must be disposed of in the proper solvent waste containers.
3.1 General Laboratory Procedures

There are many users of the Physics Department Laboratories. Common courtesy, common sense, respect for others, knowledge of the hazards, and cleanliness are all essential parts of laboratory operation.

3.1.1 Behavior In The Laboratory

1. Laboratory users shall act in a professional manner at all times.
2. Horseplay and practical jokes are expressly forbidden.
3. Never work alone at a potentially dangerous activity.
4. Visitors to the laboratory must observe all safety regulations.
5. Laboratory users shall be aware of the location and proper operation of laboratory safety and emergency equipment.
6. Any chemicals in a hood must be labeled and have the user’s full name printed on a clean room wipe, the date, and the chemical contained in the beaker or bottle.

3.1.2 Avoidance Of Routine Exposure

1. Always avoid skin contact with chemicals.
2. Do not smell or taste chemicals.
3. Never pipette by mouth. Use a vacuum or a pipette bulb.
4. Apparatus which may discharge chemical vapors or dust that might produce adverse toxic effect must be vented into local exhaust ventilation devices.
5. Chemical reactions involving two or more substances may form reaction products that are significantly more toxic than the starting reactants. Always assume that all substances of unknown toxicity are toxic.
6. Always use common sense, respect, good judgment, professional expertise and safety awareness when it comes to hazardous chemicals.

3.1.3 Personal Habits In The Laboratory

1. Eating, drinking, chewing gum and cosmetic application are not permitted in the laboratory.
2. Smoking is not allowed in the Stevenson Center at Vanderbilt.
3. Food must not be stored in a refrigerator with chemicals. Do not use glassware or utensils which are used in laboratory operations for storing or serving food products.
4. Wash hands before using the restrooms, eating, drinking, or smoking.

3.1.4 Unattended Operations

1. Only well understood processes should be permitted to run unattended, at the discretion of the Principle Investigator.

3.1.5 Housekeeping
1. Clean up after yourself (dispose of chemicals, wipes, pipettes, etc.).
2. Lab areas (benches, hoods, tables, etc.) will be kept clean and uncluttered.
3. Any spills or accumulations of chemicals on work surfaces shall be removed as soon as possible with techniques that minimize residual surface contamination in the laboratory.
4. Lab floors and walkways should be kept dry at all times.
5. Doorways and walkways shall not be blocked or used for storage.
6. Access to exits, emergency equipment, and utility controls shall never be blocked.
7. For those that do not follow the rules, there are penalties:
   a) 1st time offense: The safety compliance officer will pick up your glassware, chemicals, samples, etc and you will have to see the safety compliance officer before you get the items back.
   b) 2nd offense: The safety compliance officer will pick up your glassware, chemicals, samples, etc and you and your advisor will have to make an appointment to see the safety compliance officer before you get the items back.
   c) 3rd offense: The safety compliance officer will pick up your glassware, chemicals, samples, etc and you and your advisor will have to go before the Physics Safety Committee.

3.1.6 Personal Protection

There are numerous hazards in the laboratory. Each user is responsible for and required to use and know the types of personal protective equipment (PPE) available. Everyone entering the laboratory must wear the appropriate eye protection (i.e., safety glasses with side shields).

3.1.7 Glassware

Glassware is used throughout the laboratory. Care should be taken in the handling and usage of glassware. Before use, the glassware should be inspected for any defects and cracks. Several pieces of the glassware in the laboratory have ground joints. These joints should never be put on tightly, especially at temperature extremes, because this action can cause them to get stuck. All broken glassware (beakers, pipettes, silicon wafers, etc.) should be disposed of in the appropriate waste container labeled "Broken Glass."

3.1.8 Working With Vacuum

In a vacuum system, the higher pressure is on the outside, rather than on the inside, so a break can cause an implosion rather than an explosion. The resulting hazards consist of flying glass and damage from this debris. Special precautions including eye protection are required when working with vacuum.
3.2.0 Chemicals

Each laboratory will assign an individual to insure compliance with the Vanderbilt chemical waste management policy and to oversee waste collection in that laboratory. This individual will be known as the laboratory compliance officer. The Department will include that individual’s performance in that area with their overall performance evaluation.

All users of the laboratory should know as much as possible about the chemicals being handled and used in process equipment during research experiments. All researchers should read the container label, material safety data sheets, literature in the library and/or consult with your supervisor, fellow researchers, PI or the Chemical Hygiene Officer at the VEHS Office.

The MSDS list for all the chemicals in a department laboratory must be maintained by the laboratory’s compliance officer. MSDS sheets for all chemicals used inside the laboratory are maintained in a hardcopy form for general access. These MSDS sheets are located there for emergencies and should only be removed from the binders in an emergency. If you need a MSDS for reference purposes, please contact the laboratory’s compliance officer.

If you buy or acquire a new chemical and bring it into departmental labs, you are responsible for obtaining the MSDS sheet and submitting a copy of it to the laboratory’s compliance officer. The Material Safety Data Sheets are maintained by the laboratory compliance officer for all chemicals used in the laboratory. Chemicals that are specially ordered for your project/your professor should be labeled as such with your name, date, and professor or person responsible for it. Small amounts of chemical solutions that are made up and stored must be labeled. The label will have your name, date and chemical composition. All flammable solvents must be stored in designated solvent cabinets located in each laboratory.

Chemical guidelines for use in departmental laboratories on the benches and hoods:

1. All containers with chemicals must be labeled
2. A clean room wipe with your full name and date must be under all containers with chemicals in them.
3. When using a bottle containing a chemical, use all of it before opening a new bottle.

3.2.1 Procurement

1. All chemicals used and brought into the department laboratories must have the approval of the Laboratory PI.
2. Prior to purchasing chemicals, the researcher must consider the following criteria: a. Proper storage and handling procedures; and
b. Are facilities adequate to safely handle the material?
3. A Material Safety Data Sheet (MSDS) will be required for all chemicals brought into the department laboratories. This requirement is the responsibility of the person bringing the chemical into the department laboratory. Check with the laboratory compliance officer to see if the MSDS for the chemical in question is already on file.
4. No chemical will be allowed in the laboratory without an identifying label.
5. Order only what you need;
6. All chemicals brought into the laboratory by a user must have a date on the chemical container when ordered and the person responsible for it.

3.2.2. Chemical Waste Disposal

Each user working in the laboratory has a responsibility to see that all chemical wastes are disposed of properly.

1. All solvents must be put in one of the solvent waste containers or cabinets located in each lab.
2. All waste products and residues must be placed in the appropriately designated and labeled waste container in the waste accumulation area for proper disposal.

If you have any question about disposal of specific waste products or residues from experiments (this question must be answered prior to starting your work) contact your Advisor or VEHS. Never leave any chemical container uncapped, especially waste containers.

3.2.3 Chemical Handling

1. When chemicals are hand carried, the primary container (i.e., the bottle) should be placed in a secondary container (i.e., a bottle carrier) to protect from breakage and spillage.
2. Freight elevators should be used when possible to prevent exposure to people on passenger elevators.
3. If a wheeled chemical cart is used, it should be stable under the load and have wheels that are large enough to handle uneven surfaces without tipping over or stopping suddenly.
4. The chemical cart should have secondary containment spaces to prevent the spillage of chemicals in the event that a bottle breaks.

3.2.4 Solvents

Solvents are a necessary part of the laboratory processes and have the potential for causing a considerable amount of damage, if handled incorrectly. All solvent containers are limited to 1 gallon or less. The solvent containers shall always be stored in designated flammable solvent.
3.2.4.1 Hazards

1. Vapors from some organic solvents can form an ignitable mixture in air.
2. Many flammable liquids or organic solvents are potentially hazardous to researchers by inhalation.
3. Skin contact with organic solvents should be avoided, irritation or skin absorption are possible with some flammable chemicals.
4. Damage to the eyes from contact with solvents range from irritation to severe chemical corrosion damage.

3.2.4.2 Storage

Store all flammable liquids and solvents in appropriate cabinets.

3.2.4.3 Controls

1. Chemicals must be used in a locally exhausted fume hood.
2. Spills must be cleaned up immediately and the spill area must be properly decontaminated.
3. Emergency showers and eyewashes shall be used when skin or eye contact occurs. Get first aid attention immediately for any chemical exposure.
4. Hotplates that are not intrinsically safe should never be used to heat flammable liquids.

3.2.5 Corrosive Chemicals

A corrosive chemical is a chemical that causes visible destruction of, or irreversible alterations in, living tissue by chemical action at the site of contact.

3.2.5.1 Hazards

Contact with skin, eyes, respiratory or digestive tract causes severe irritation or burns.

3.2.5.2 Storage

Store all acids and bases in appropriate cabinets, which are located in each lab.

3.2.5.3 Controls

1. Wear protective clothing: goggles or safety glasses with side shields, face shield (when pouring), lab apron and sleeves, and latex or nitrile gloves.
2. Never add water to concentrated mineral acids or bases – add the acid or base to water.
3. In case of skin contact:
   • Flush affected area with large amounts of water for at least 15 minutes.
• Remove contaminated clothing.
• Seek medical attention immediately.

3.2.6 Reactives

A reactive (unstable) chemical is one which, in the pure state, or as produced or transported, will vigorously polymerize, decompose, condense or will become self-reactive under conditions of shock, elevated pressure or temperature.

3.2.6.1 Hazards

1. Water sensitive chemicals react violently in the presence of water.
2. Pyrophoric materials may ignite in air at or below room temperature in the absence of added heat, shock or friction.

3.2.6.2 Storage

1. Store water reactives according to label directions.
2. Pyrophoric chemicals should be stored in an atmosphere of inert gas.

3.2.6.3 Controls

1. Wear proper safety equipment.
2. Read precautionary label.
3. Use only in a hood/glove box.

3.2.7 Compressed Gases

The laboratories have numerous compressed gas cylinders for various applications located throughout Stevenson Building 6. The pressure inside some of these cylinders can be as high as 2500 pounds per square inch gauge (psig). Procès gas cylinders are stored in designated areas, such as the cylinder storage facilities on the Stevenson Science Center loading dock.

3.2.7.1 Hazards

Compressed gases may be flammable, pyrophoric, toxic (or highly toxic), corrosive, oxidizing or inert. Because of the significant pressure present in a full gas cylinder, a gas cylinders with a broken valve (e.g., from dropping a cylinder) can become a missile capable of penetrating walls.

3.2.7.2 Handling, Storage And Use

General Standards
1. All compressed gas cylinders must be secured in a gas cabinet or to a wall or a lab bench using a cylinder restraint.
2. Only trained and designated persons may change or service gas cylinders, regulators or gas lines.
3. All cylinders containing toxic, corrosive, pyrophoric, flammable and oxidizing gases should be equipped with safety caps to protect the cylinder valve and to prevent leaks of gas through the cylinder outlet connection.
4. Only Compressed Gas Association (CGA) standard combination of valves and fittings may be used in compressed gas installations.
5. The valve protection cap and the dust cap should be left on the cylinder until it has been secured and is ready for use.
6. Cylinders shall be clearly marked with the content name. Do not remove or deface labels, decals, etc., provided by the supplier for identification.
7. Avoid dragging, rolling, or sliding cylinders, even for a short distance. The only movement should be minimal alignment from cart to final position. Cylinders should be moved by using a suitable compressed gas cylinder hand truck/cart.
8. Cylinders should be stored in a secure manner in areas away from extreme temperature changes, sources of ignition, moisture and mechanical shock.
9. A pressure regulator shall be used to control the flow of gas from a cylinder.
10. Never attempt to repair or alter cylinder valves or safety relief devices.
11. No new gas cylinder set up may be installed in department labs without the review and approval of the Lab PI or laboratory compliance officer.
12. If you need help in addressing a gas cylinder problem, contact properly trained personnel for assistance.
13. Empty cylinders must be clearly marked as empty and returned to the designated gas cylinder storage room for interim storage.
14. Empty gas cylinders must be handled with caution since they are never fully empty.

General Guidelines for Pressure Regulators and Gas Cylinder Components

• Needle valves and regulators are specifically designed for different families of gases.
• Use only the properly designed fittings.
• Threads and surfaces must be clean and tightly fitted.
• Do not lubricate gas cylinder fittings.
• Tighten regulators and valves firmly with the proper size wrench (Avoid using adjustable wrenches or pliers, as they can damage cylinder fittings).
• Do not force tight fits.
• Open valves slowly.
• Do not stand directly in front of the gauges. (Gage face may blow out).
• Do not force frozen valves.
• Shut off cylinders when not in use.

Leak Testing
Cylinders and connections should be tested using “Snoopy” or a soapy water solution to assure that no gas leaks are present.

3.2.8 Liquid Nitrogen

Individuals working with liquid nitrogen should wear eye protection and gloves or use protective thermal pads to avoid cryogenic burns.

IMPORTANT SAFETY NOTE:

All Physics lab users should be especially mindful that leaks (even small leaks) of liquid nitrogen (or any other inert gas) can easily result in the creation of an oxygen deficient environment (which can be immediately dangerous to life and health [IDLH]) for researchers in spaces and rooms that are not well ventilated. Before using liquid nitrogen dewars or cold traps, a thorough process hazard review should be completed on the experimental set up, to assure that a potential IDLH environment has not been created.

3.3 Equipment Safety

3.3.1 Solution Heaters – Immersion Heaters:

1. Immersion heaters must be an integral part of a heater-controller system.
2. For in situ heating, use Teflon coated immersion heaters only.
3. Controllers must be equipped with the following safety features:
   a) Thermistor-controlled solution temperature
   b) Single set-point latched system
   c) P-lm thermocouple heater control-separate wiring
   d) Twist lock plug from heater to controller (no other type permitted)
   e) Bipolar plug to 20 amp outlet
4. Quartz heaters are prohibited, unless specifically authorized by VEHS.

3.3.2 Hot Plates:

1. Containers to be heated on hot plates should be no larger than the dimensions of the hot plate surface.
2. Where circular bottomed beakers are placed on square or rectangular hot plates, the diameter of the beaker should be no greater than the smallest dimension of the rectangle.
3. Appropriate quality glass should be used for hot plate heating.
4. Inspect all glassware for surface flaws or imperfections. Imperfections can cause the glass to shatter upon heating.
5. Flammable liquids should not be heated on hot plates that are not rated for flammables.

3.3.3 Heating Mantles:

1. Mantles should be used for heating solutions or oils to high temperatures in round bottom flasks.
2. See the manufacturer’s specifications for mantle performance.
3. Correctly match the mantle size with the vessel bottom shape and size.
4. Make sure the fit is snug over the entire surface of the vessel.
5. Do not use mantles with frayed cords.

3.3.4 Oil Immersion Heating Baths:

1. Check the manufacturer’s specifications for the oil immersion heating bath.
2. Hot oil circulators require the use of securely attached high temperature tubing, preferably flexible stainless steel with an inert lining.
3. Oil type and quality should be reviewed periodically. Pay particular attention to the appropriate working temperature range for the work to be done.
4. Discard old oil baths after discoloration begins to occur, or after several uses at high temperatures.
5. Check the viscosity of the oil to ascertain its quality.

3.3.5 Water Baths:

1. Water baths must be checked (e.g. pitting, rust, holes and water level) prior to use.
2. The bath line should match the vessel solution line.
3. For heating flammable liquids, monitor the temperature of the bath frequently during an analysis.
4. 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 (it may be significantly different than the temperature achieved by an aqueous solution at the same temperature).

3.3.6 Electrical Safety:

1. Electrical equipment used with flammables must be rated class 1, division 1. A plate on the equipment will state its rating, if so rated.
2. Electric power receptacles for operations conducted in hoods must be located outside the hood.
3. Inspect equipment prior to use and replace any frayed cords
4. Label defective electrical items to prevent their use while waiting for repair.
5. Extension cords should only be used when necessary. Temporary use is allowed. Permanent use in lieu of permanent wiring is not allowed.
6. Extension cords must not lie across aisles.
7. Switch off all appliances before removing plugs from outlets in order to avoid voltage surges when plug is reinserted into the outlet.
8. All appliances must have grounded plugs.

3.3.7 Drying Ovens:

1. Volatile materials should not be dried in a conventional laboratory oven unless the oven has continuous ventilation of the atmosphere inside the oven.
2. Explosion Proof drying ovens with rear blowout panels should be used for volatile materials.

3.3.8 Refrigerators:
1. Laboratory refrigerators must never be used for the storage of food or beverages.
2. Explosion-Proof refrigerators are to be used for storing flammable or combustible materials.
3. Uncapped containers should never be placed in a refrigerator.

3.3.9 Stirring And Mixing Devices:
1. Only spark-free induction motors should be used to run stirring and mixing devices.
2. Stirring motors that will be left unattended should be fitted with a suitable fuse or thermal protection device.

3.3.10 Nitrogen Purged Glove Box:
1. Detailed procedures for the safe operation of Nitrogen Purged Glove Boxes must be developed.
2. Detailed procedures for the safe maintenance of the Nitrogen Purged Glove Boxes must be developed.
3. Detailed procedures for responding to emergency leak events of the Nitrogen Purged Glove Boxes must be developed.

3.4.0 Personal Protective Equipment

The laboratory PI (or authorized representative) will be responsible for the selection of personal protective equipment (PPE), acquiring approved equipment, maintaining availability, and establishing cleaning and disposal procedures. Chemical protective clothing must be removed before leaving the work area.

* Laboratory personnel must know the types of PPE available and use the proper type of equipment for each job. Everyone, including visitors, must wear the appropriate eye protection (i.e. safety glasses with sideshields) when entering the department laboratories where chemicals are stored or handled.
* Wear appropriate gloves and other PPE when handling hazardous chemicals.

3.4.1 Eye Protection
1. Safety glasses with side shields are required in all departmental labs.
2. Face shields with safety glasses underneath or chemical splash goggles are required when transferring or pouring acid or caustic materials, or where a potential splash hazard exists.
3. Inspect before each use the eye and face protection equipment you plan to use. If there is any damage, cracks, debris, or scratches do not use it! Notify laboratory personnel immediately concerning defective PPE.

3.4.2 Gloves

1. Chemical resistant gloves shall be worn whenever the potential for skin contact with hazardous materials exists.
2. Gloves shall be removed before touching other surfaces (door knobs, telephone receivers, faucet handles).
   a. Heat resistant gloves shall be used for handling hot objects.
   b. Low temperature gloves specifically designed for cryogenic use shall be worn when handling materials like dry ice or liquid nitrogen.
3. Before each use, gloves are to be inspected for damage and contamination. If there are any signs of damage, cracks, or contamination do not use the gloves and notify laboratory personnel immediately.

3.4.3 Clothing

1. No sandals or open-toed or open heeled shoes are to be worn in any lab. Canvas shoes should be avoided.
2. The shoe should have a non-skid sole and should have a reasonable heel height.
3. Skirts and shorts are not allowed to be worn in the laboratory as they provide little protection from a potential splash or chemical spill.

3.4.4 Respirators

If any lab user has a need for a respirator, please consult with VEHS for the selection of this very special type of Personal Protective Equipment (PPE). There are specific regulatory requirements that must be complied with when respirators are worn by departmental researchers.

3.4.5 Employee Training (PPE)

Employees should not use any Personal Protective Equipment until they have received instruction on the proper selection, use, and limitations of the equipment.

3.5.0 Emergency Equipment

3.5.1 General

Each Physics laboratory user shall be familiar with the location of the Fire Alarms (Pull Stations), Emergency Gas Off (EGO) buttons, Toxic Gas and Fire Alarm annunciators, telephone, emergency numbers, and chemical containment materials.
3.5.2 Safety Showers And Eye Washes

There are safety showers and eye wash stations in the department laboratories. When first using the department laboratories, all researchers should familiarize themselves with these important emergency equipment locations.

3.6.0 Emergency Procedures

No single emergency plan will be adequate for all emergency situations. The most important component of emergency planning is prevention. Prevention measures range from employee training to facility audits and inspections. If a fire alarm sounds, all persons are to leave the Physics laboratory immediately. Never assume that an evacuation alarm is indicative of a drill. If there is any question about any situation or something happening in the laboratory, always ask your PI, laboratory compliance officer or others about what to do. It is better to err on the side of caution.

3.6.1 Emergency Reporting Procedures

Call the Vanderbilt University Police Department (at Ext. 1-1911) for all emergencies. They will dispatch the Police, Fire Department, medical aid, or VEHS.

FOR ALL EMERGENCIES DIAL: 1-1911

When reporting an emergency, give as much information as possible, such as:

1. Location and type of emergency
2. Name of victim(s) (if necessary)
3. Your name
4. Extension number of caller
5. If a chemical is involved, write down the name of the chemical to give this information to emergency personnel.
6. If possible, remain at the scene to help explain what happened when emergency responders arrive.

3.6.2 FIRST AID And MEDICAL ATTENTION

Accidents or injuries, which occur in the Departmental laboratories and require medical treatment, should be treated immediately. During normal working hours (8-5, M-F) contact laboratory personnel for assistance and Vanderbilt hospital emergency room will administer medical attention or make a referral for other treatment or facilities. After hours, VUPD (at 11911) should be contacted. For accident victims who need medical care beyond first aid, call VUPD (at 11911) for transportation to the proper medical facility. In any case where you are not sure of the severity of the injury or where the
employee should be referred to, they should be immediately sent to Vanderbilt Hospital emergency room.

FIRST AID PROCEDURES

1. CHEMICAL BURNS: Flush the affected area with cold water for at least 15 minutes. Flush eye for at least 15 minutes at an eye wash station or sink.
2. THERMAL BURNS: Immerse the burned area in cold water or apply ice until the pain stops. Cover with a sterile dressing.
3. POISONS: Call the Poison Center (1-800-322-9675) for assistance in administering poison antidotes.
4. BLEEDING: Hold a clean cloth pad directly on the wound and apply hand pressure. Apply a tourniquet only as a last resort.
5. FIRES: Put out burning clothing or hair with a fire blanket or water. If these resources are not available, make the victim roll on the ground to put out the flames.

3.6.3 Chemical Spills

When laboratory spills occur, it is necessary to take prompt and appropriate action.

Appropriate action will depend on the severity of the hazards associated with the particular chemical spilled.

1. If the spill is minor and of known limited danger, begin the cleanup operation immediately.

2. If the spill is unknown in chemical composition or potentially dangerous (explosive, toxic fumes), evacuate the room and call VEHS at 322-2057 or after hours to VUPD at 11911.

3. If it is suspected or known that the spill is extremely dangerous:
   a. Call VUPD (at 11911) who will alert the Fire Department and VEHS.
   b. Evacuate the building by pulling the nearest Fire Alarm Pull Station. See the Fire Alarm & Emergency Equipment Locations shown in Appendix B of this manual for pull station locations.

3.6.4 Chemical Spill Cleanup

Spill control begins by spreading an appropriate absorbent material on the spill. Spill cleanup kits should be stocked in each departmental laboratory. Kits are made specifically for various hazard classes of chemicals. Each physics laboratory must have appropriate spill absorbents available in the lab for the types of chemicals that are stored or used in those respective laboratory areas. Be sure to call VEHS for disposal procedure or pickup of spill clean up materials. If in doubt about the proper spill cleanup procedures, call VEHS at 322-2057.
4.0 Laboratory Specific User Training

All new users of the department laboratories must read and understand the Physics Safety Plan before access to the laboratory and equipment is granted.

4.1 Chemical Training

It is the responsibility of the laboratory user to become familiar both the hazards and the safe operating practices that are to be used when working with the chemicals in the lab.

4.2 Equipment Training

There are numerous users of the equipment in the department laboratories and, as such, certain pieces of equipment have logbooks. To use this equipment, a user must follow the procedures for the equipment and logbook. If you do not follow the procedures for the equipment usage your authorization to use the equipment will be denied.

1. Equipment with signup sheets and logbooks must be filled out completely.

2. Only “authorized users” are allowed to sign up and use equipment. (Personnel that are trained on the equipment by staff or faculty are considered “authorized users”.)

3. If you are not an authorized user, DO NOT USE THE EQUIPMENT!

4. Authorized users are NOT allowed to train others.

5. Report any equipment problems as they occur, give a complete description of the problem (e.g., “It’s broken” or “doesn’t work” is not a description of the problem.). Sending an e-mail message to the lab compliance or notifying a technician, are good ways to report your problems. Include the equipment name, date, problem and time.

6. If you pull out equipment, racks, carts, step stools, etc. replace them in their proper position.

7. Keep the area around instruments and equipment clear of obstructing materials.

8. Equipment with frayed electrical cords should be reported immediately.
5.0 Laser Safety

(On-line training is required for ALL faculty, staff and students who work with lasers!)

http://www.safety.vanderbilt.edu/training/laser/laser_safety.htm

There are many kinds of lasers and numerous applications. In addition, the relationships between emitted radiations and harmful effects can be complicated. In order to simplify the implementation of control measures, laser radiation hazards are rated on a scale from (Class I) (safe) to Class 4 (Class IV) (dangerous). It is unlikely that a hazard Class 1, 2, or 3a laser would cause an inadvertent injury. On the other hand, hazard class 3b and 4 lasers have a significant potential for causing accidental injuries. Not surprisingly, most control measures are associated with these higher class systems.

Class 3b (IIIb) and Class 4 (IV) laser systems are primarily utilized in scientific applications. For example, Class IIIb nitrogen lasers are used as a source of pulsed ultraviolet radiation for calibrating scintillation detectors. Class IV Nd:YAG (and similar) lasers are also used in material applications and for direct photon-particle interactions. Lasers used in commonly-encountered commercial applications such as bar code scanners, pointers, alignment systems, CD/DVD systems, and fiber optic communication systems tend to be Class II or Class IIIa diode lasers.

Radiation from Class I lasers cannot cause injury while that from Class II lasers can only damage the eye upon prolonged direct viewing. Accordingly, precautions for using these devices are minimal, but students or researchers employing Class II devices should be made aware of the risks.

Class III lasers are capable of causing eye injury before an exposed person can react and Class IV lasers can cause skin injury and even diffuse reflections from such devices can cause eye injuries. Special training/instruction/precautions (from a combination of the Principle Investigator or their designated Laser Safety Officer (LSO) or other qualified personnel) is required in order to use these more hazardous lasers. Precautions for Class III and Class IV lasers include direct supervision by a qualified laser operator, warning signs and lights, locking the laser when not in use, interlock mechanisms for lasers in controlled environments, and protective eyewear.

The descriptions and precautions listed below are meant to inform the casual reader to the hazards present in laser operation in the Physics and Astronomy Department at Vanderbilt University. Specific requirements at Vanderbilt are covered in the on-line training from the Vanderbilt Environmental Health and Safety. On-line training required for ALL faculty, staff and students who work with lasers!

1. HAZARD CLASS I

a. Description:
Any laser that requires more than eight hours of direct eye exposure to produce an injury is considered harmless. The maximum output of a class 1 visible wavelength Continuous Wave (CW) laser ranges from 40 to 400 mW, depending on wavelength.

b. Precautions

Usually none. However problems may arise if the laser is modified in a way that may increase its output or there is an embedded laser that has a higher hazard class. If these are encountered, follow the precautions for the appropriate hazard class.

2. HAZARD CLASS 2

a. Description

A laser that emits radiation in the visible portion of the spectrum and requires more than 0.25 seconds of direct eye exposure to produce a retinal lesion. Since the bright light emitted from such a device triggers a "blink reflex," and most people can blink within 0.15 seconds, an injury can only occur by forcibly staring into the beam. Considered low hazard. The body has a mechanism to protect itself and significant retinal damage requires prolonged staring. The maximum output of a class 2 CW laser is 1 mW. The wavelength of the radiation must be within the visible portion of the spectrum (0.4 to 0.7 m).

b. Precautions

Do not stare into the beam. Do not point the laser in the direction of other people or shiny objects. Precautions for public displays apply (see definitions). As with hazard class 1 lasers, problems may arise if the laser is modified in a way that may increase its output or there is an embedded laser that has a higher hazard class. If these are encountered, follow the precautions for the appropriate hazard class.

3. HAZARD CLASS 3a

a. Description

A laser that has 1 to 5 times the output of a class 1 laser in the invisible portions of the spectrum (<0.4 m or >0.7 m), or 1 to 5 times the output of a class 2 laser at visible wavelengths (0.4 to 0.7 m). In addition, the applicable exposure limit must not be exceeded, e.g., due to large beam diameter. For example, a class 3a visible wavelength CW laser can have an output of 1-5 mW, as long as the totalance does not exceed 2.5 mW/cm². Considered a moderate hazard.

b. Precautions

Do not stare at the beam or view directly with optical instruments. Do not point the laser in the direction of other people or shiny objects. Special care for public displays is advised. As with hazard class 1 lasers, problems may arise if the laser is modified in a way that may increase its output or there is an embedded laser that has a higher hazard class. If these are encountered, follow the precautions for the appropriate hazard class.

4. HAZARD CLASS 4a
a. Description
Any laser that exceeds hazard class 3a, but less than class 4. At visible and infrared wavelengths (>0.4 μm), a 3b laser can cause eye injury within the time it takes to blink. This applies to the direct beam or a beam that is reflected from a specular surface. A class 3b visible wavelength laser has an output of 2 to 500 mW. UV lasers (<0.4 μm) have a relatively lower threshold for hazard class 3b - 0.1 to 10 μW. Consequently, much longer exposures are required to produce an injury near this threshold. A class 3b laser is considered hazardous.

b. Precautions
- Avoid eye exposure to the direct or reflected beam.
- Any personnel deemed appropriate by the principal investigator (or I.S.O) responsible for the operation of the laser should be notified prior to operation.
- Laser training is required for persons who may be exposed to the beam while operating, maintaining, or servicing the laser.
- Try to reduce the hazard class by enclosing the beam path, especially for extended/repeated operations in a single location. Enclosure is typically in the best interest of the laser operator since it simplifies safety requirements and reduces the likelihood of damage to the laser set up. Enclosures must be interlocked or locked to prevent inadvertent exposure.
- Establish a controlled area during periods of unenclosed operation. Spectators should not be permitted within the controlled area unless (1) approval has been obtained from the laser operator, (2) the degree of hazard and avoidance procedures have been explained to them, and (3) appropriate protection measures have been taken. Precautions for public displays must be thorough.
- Wearing of appropriate laser eye protection is recommended, but not required.
- Post signs during periods of unenclosed operation.
- Exercise special care (1) during alignment, (2) when using invisible beams, and (3) where people who are not involved with the operation can be exposed to the beam.

5. HAZARD CLASS 4

a. Description
Any laser where diffusely scattered radiation can cause eye injury within 0.25 seconds. In other words, radiation scattered from a rough surface can cause eye damage within the time it takes to blink. Additionally, depending on output characteristics, class 4 lasers can damage skin, ignite fires, and thermally decompose irradiated materials. A class 4 laser presents a significant hazard that must always be treated with great care. A continuous wave laser of any wavelength with an output exceeding 0.3 W is considered to be class 4.

b. Precautions
- Avoid eye and skin exposure to the direct or scattered beam.
- Operation requires the prior approval of the Laser Safety Officer and any other personnel deemed appropriate by the Principal Investigator responsible for the operation.
of the laser. This is typically accomplished via review and approval of written safety operating procedures that are required in any case.

Laser training is required for persons who may be exposed to the beam while operating, maintaining, or servicing the laser.

Make every effort to reduce the hazard class by enclosing the beam path, especially for extended/repeated operations in a single location. Enclosure is typically in the best interest of the laser operator since it simplifies safety requirements and reduces the likelihood of damage to the laser set up. Enclosures must be interlocked or locked to prevent inadvertent exposure.

Establish a controlled area during periods of unenclosed operation. Spectators must not be permitted within the controlled area unless (1) approval has been obtained from the laser operator, (2) the degree of hazard and avoidance procedures have been explained to them, and (3) appropriate protection measures have been taken. Precautions for public displays apply (see definitions).

Use an audible or visual start up warning to alert others that the laser will be activated.

ALWAYS wear appropriate laser eye protection within the controlled area during periods of unenclosed operation. This is a critical precaution. Scattering of the beam from any surface may be able to produce an eye injury within the time you can blink.

Post signs during periods of unenclosed operation.

Exercise special care (1) during alignment, (2) when using invisible beams, and (3) where people who are not involved with the operation can be exposed to the beam.

Initial laser system installation or subsequent modification, including changes in usage or location, must be brought to the attention of the LSO and Principal Investigator.

6. NON-BEAM HAZARDS

Non-beam hazards are those that do not result from exposure to a laser beam. Non-beam hazards must be considered in the use of lasers. These hazards include the following:

Laser components (power supplies)

Materials used to generate the laser beam (gases, dyes, solvents)

Materials exposed to the beam (fires, thermal decomposition products)

Laser environment (mechanical hazards, confined spaces)
6.0 Radiation Safety

Nuclei that are unstable emit radiation as they decay. Materials containing unstable radioactive nuclei that emit radiation are called radioactive materials. Radioactive material in an unwanted place is called radioactive contamination. The four common types of ionizing radiation are alpha, beta, neutron and gamma. Each type of ionizing radiation presents different hazards. Table A gives characteristics of these ionizing radiation types.

<table>
<thead>
<tr>
<th>Type</th>
<th>Alpha</th>
<th>Beta</th>
<th>Gamma</th>
<th>Neutron</th>
<th>500 kV X-ray</th>
</tr>
</thead>
<tbody>
<tr>
<td>Penetrating Power</td>
<td>Very Low (1-2&quot; in air)</td>
<td>Low (10-12&quot; in air, few mm in skin)</td>
<td>High (several hundred feet in air)</td>
<td>High (several hundred feet in air)</td>
<td>High (several hundred feet in air)</td>
</tr>
<tr>
<td>(range)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shielding</td>
<td>1&quot; of air, outer layer of dead skin, clothing</td>
<td>Aluminum Glass Plastic Safety Gasses</td>
<td>Concrete Lead Steel</td>
<td>Hydrogenous Materials: Water Concrete Polyethylene</td>
<td>1 cm Lead 10 cm Concrete</td>
</tr>
<tr>
<td>Biological Hazard</td>
<td>Internal</td>
<td>Internal, Skir, Eyes</td>
<td>External (whole body)</td>
<td>External (whole body)</td>
<td>External (whole body)</td>
</tr>
<tr>
<td>Quality factor</td>
<td>20</td>
<td>1</td>
<td>1</td>
<td>Eν&lt;10keV, 3 Eν&lt;10keV, 10</td>
<td>1</td>
</tr>
</tbody>
</table>

6.1 Radiation Units and Dose Limits

Understanding and minimizing biological effects of radiation are important. Biological effects are a function of the amount and type of radiation absorbed. The rad (Radiation Absorbed Dose) is a measure of the absorbed dose for any material (1 rad = 6.24 x 10⁶ MeV/g = 100 ergs/g = 0.01 J/kg.) Since the rad does not consider the potential effects that different types of ionizing radiation have on the body, the rem (Rotgen Equivalent Man) is used to characterize dose equivalence by weighting the absorbed dose (rad) for the relative biological effectiveness. The dose equivalent (rem) is the product of the absorbed dose (rad) and an appropriate (dimensionless) quality factor for the type of ionizing radiation involved. A convenient unit is the millirem (mrem = 10-3 rem), and a common unit of dose equivalent rate is the mrem/hr.

The total average annual dose equivalent from natural and man-made radiation sources is approximately 360 mrem. About 80% comes from natural background, 2/3 of which is due to radon gas. For perspective, 50% of people exposed to >500 rad over a short time period would die with 60 days with no medical attention.
The SI system of radiological units (Becquerel, gray, sievert) is also used, and definitions and conversions are given in Table B.

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Name</th>
<th>Symbol</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activity</td>
<td>Becquerel</td>
<td>Bq</td>
<td>1/sec 3.7 x 10(^{10}) Bq</td>
</tr>
<tr>
<td></td>
<td>(curie)</td>
<td>Ci</td>
<td></td>
</tr>
<tr>
<td>Absorbed Dose</td>
<td>Gray</td>
<td>Gy</td>
<td>1/10^4 Ci</td>
</tr>
<tr>
<td></td>
<td>(rad)</td>
<td>Rad</td>
<td></td>
</tr>
<tr>
<td>Dose Equivalent</td>
<td>sievert</td>
<td>Sv</td>
<td>1/10^4 Gy</td>
</tr>
<tr>
<td></td>
<td>(rem)</td>
<td>rads</td>
<td></td>
</tr>
</tbody>
</table>

To minimize personnel radiation exposure, VU operates under the As Low as Reasonably Achievable (ALARA) policy. The VU ALARA control level is set each year and is typically 600 rem for an individual. Reducing experimental radiation dose includes:

- Minimize exposure time
- Maximize distance from radiation source
- Use Shielding
- Reduce source intensity

### 6.2 Designation of area

A Controlled Area is any area where access is managed due to the presence of radioactive materials or radiation. All radioactive sources must be stored in appropriate secured storage locations.

If you encounter a radiological spill, you should:

- Stop the spill, if qualified
- Warn other personnel in the area
- Isolate the area
- Minimize your own exposure
- Notify Radiation Protection personnel

### 6.3 Use of Radioactive Sources

Arrangements must be made prior to shipping any radioactive materials to or from Vanderbilt. These sources must be shipped through Radiation Safety Office. Most sources used in the physics laboratories are sealed sources and have activities that are very low. These sources are called exempt sources and one does not need the Radiation safety committee approval prior to importing. They do not pose any hazard. These sources are sandwiched between two Lucite disks. For handling these sources, one
doesn’t have to wear gloves, provided one handles them carefully. One should not touch the central part of the disk where the sources is located. Some laboratories may use 137 Cs generators. The half-life of 137 Cs is 31 yrs. It decays to an excited state 137 Ba. The half-life if the excited state is 2.7 minutes. While handling the source one should wear gloves. Once has to be careful with 137 Cs generators. If it leaks, notify immediately the radioactive source custodian and follow the procedures outlined in section 3. The radioactive source custodian must maintain an inventory of all the sources in the Physics Department. He should also with the help of the Radiation safety office discard the dead sources and remove them from the inventory list. Radiation sources should be placed only the control of a Radioactive Source Custodian even if it is bought for personal research. This requirement includes sources shipped in by users.

Procedural Requirements

A. No radioactive source can be brought into the VU Physics Department without prior approval of the Source Custodian.

B. Radioactive sources must be stored in well-defined, secure, posted storage areas under the control of the authorized Radioactive Source Custodian.

C. Individuals who use radioactive sources must use gloves, and safety glasses. No eating or drinking in the labs while using radioactive sources.

6.4 X-ray Hazards

X-rays result from the acceleration of electrons in a vacuum and their subsequent collision with interior surfaces. As a general rule, X-rays may be produced by equipment that operates with 10 kV or more in a vacuum. All activities with potential for generating X-rays need to be evaluated to ensure that appropriate controls are in place to mitigate the hazard.
7.0 Biosafety in Physics

More than ever physics is being used in biology and medicine. The physics of life, known as biophysics, has become an integral part of many physics and engineering programs. Research in the field of biophysics spans many scales and often requires work with biologically active materials and organisms. You may find anything from living animals to human tissue samples to recombinant DNA in physics labs these days and genetically engineered bacterial based biosensors are all the rage.

Biosafety must be considered whenever experiments involve the use of known or unknown biological agents or cultures, or when an agent has been recently isolated or is suspected to be present in or on any material handled during an experiment.

A risk assessment should be performed by a person well experienced in biological safety and should be reviewed by the lab P.I. before any work with biological materials begins. Vanderbilt Environmental Health and Safety (VEH&S) should be consulted and your research or use of the biological material should be registered with them before any biological materials are ordered for your lab.

There are four levels of biosafety containment that are based on the risk factors of the biological agent in use. BSL-1 is the most basic and minimum level of containment allowed for ANY biological material. It requires very little specialized equipment and can be performed in most labs that can have controlled access and easily cleanable work surfaces. BSL-2 is the most common when culturing cells and microorganisms. It requires some specialized equipment like biosafety cabinets and requires the use of special techniques when handling samples both to prevent infection of the lab user and contamination of the sample. BSL-3 & 4 are used with highly infectious materials and require extensive training, highly specialized equipment and special permission from VEH&S.

The following descriptions are extracted from the 4th edition of Biosafety in Biomedical and Microbiological Laboratories written by the CDC.

**Biosafety Level 1** practices, safety equipment, and facility design and construction are appropriate for undergraduate and secondary educational training and teaching laboratories, and for other laboratories in which work is done with defined and characterized strains of viable microorganisms not known to consistently cause disease in healthy adult humans. *Bacillus subtilis*, *Naegleria gruberi*, infectious canine hepatitis virus, and exempt organisms under the NIH Recombinant DNA Guidelines are representative of microorganisms meeting these criteria. Many agents not ordinarily associated with disease processes in humans are, however, opportunistic pathogens and may cause infection in the young, the aged, and immunodeficient or immunosuppressed individuals. Vaccine strains that have undergone multiple in *vivo* passages should not be considered avirulent simply because they are vaccine strains.
Biosafety Level 1 represents a basic level of containment that relies on standard microbiological practices with no special primary or secondary barriers recommended, other than a sink for handwashing.

**Biosafety Level 2 practices**, equipment, and facility design and construction are applicable to clinical, diagnostic, teaching, and other laboratories in which work is done with the broad spectrum of indigenous moderate-risk agents that are present in the community and associated with human disease of varying severity. With good microbiological techniques, these agents can be used safely in activities conducted on the open bench, provided the potential for producing splashes or aerosols is low. Hepatitis B virus, HIV, the salmonellae, and *Toxoplasma* spp. are representative of microorganisms assigned to this containment level. Biosafety Level 2 is appropriate when work is done with any human-derived blood, body fluids, tissues, or primary human cell lines where the presence of an infectious agent may be unknown. (Laboratory personnel working with human-derived materials should refer to the OSHA Bloodborne Pathogen Standard(7) for specific required precautions.)

Primary hazards to personnel working with these agents relate to accidental percutaneous or mucous membrane exposures, or ingestion of infectious materials. Extreme caution should be taken with contaminated needles or sharp instruments. Even though organisms routinely manipulated at Biosafety Level 2 are not known to be transmissible by the aerosol route, procedures with aerosol or high splash potential that may increase the risk of such personnel exposure must be conducted in primary containment equipment, or in devices such as a BSC or safety centrifuge cups. Other primary barriers should be used as appropriate, such as splash shields, face protection, gowns, and gloves. Secondary barriers such as handwashing sinks and waste decontamination facilities must be available to reduce potential environmental contamination.

**Biosafety Level 3 practices**, safety equipment, and facility design and construction are applicable to clinical, diagnostic, teaching, research, or production facilities in which work is done with indigenous or exotic agents with a potential for respiratory transmission, and which may cause serious and potentially lethal infection. *Mycobacterium tuberculosis*, St. Louis encephalitis virus, and *Coxiella burnetii* are representative of the microorganisms assigned to this level. Primary hazards to personnel working with these agents relate to autoinoculation, ingestion, and exposure to infectious aerosols.

At Biosafety Level 3, more emphasis is placed on primary and secondary barriers to protect personnel in contiguous areas, the community, and the environment from exposure to potentially infectious aerosols. For example, all laboratory manipulations should be performed in a BSC or other enclosed equipment, such as a gas-tight aerosol generation chamber. Secondary barriers for this level include controlled access to the laboratory and ventilation requirements that minimize the release of infectious aerosols from the laboratory.
Biosafety Level 4 practices, safety equipment, and facility design and construction are applicable for work with dangerous and exotic agents that pose a high individual risk of life-threatening disease, which may be transmitted via the aerosol route and for which there is no available vaccine or therapy. Agents with a close or identical antigenic relationship to Biosafety Level 4 agents also should be handled at this level. When sufficient data are obtained, work with these agents may continue at this level or at a lower level. Viruses such as Marburg or Congo-Crimean hemorrhagic fever are manipulated at Biosafety Level 4.

The primary hazards to personnel working with Biosafety Level 4 agents are respiratory exposure to infectious aerosols, mucous membrane or broken skin exposure to infectious droplets, and autoinoculation. All manipulations of potentially infectious diagnostic materials, isolates, and naturally or experimentally infected animals, pose a high risk of exposure and infection to laboratory personnel, the community, and the environment. The laboratory worker's complete isolation from aerosolized infectious materials is accomplished primarily by working in a Class III BSC or in a full-body, air-supplied positive-pressure personnel suit. The Biosafety Level 4 facility itself is generally a separate building or completely isolated zone with complex, specialized ventilation requirements and waste management systems to prevent release of viable agents to the environment.

The laboratory director is specifically and primarily responsible for the safe operation of the laboratory. His/her knowledge and judgment are critical in assessing risks and appropriately applying these recommendations. The recommended biosafety level represents those conditions under which the agent can ordinarily be safely handled. Special characteristics of the agents used, the training and experience of personnel, and the nature or function of the laboratory may further influence the director in applying these recommendations.

Basic Biosafety Guidelines

Prudent practice requires that ALL biomaterials be considered pathogenic until PROVEN otherwise by a reliable laboratory. Remember you have the right to know, don’t take someone’s word for it. Investigate the origin of all samples and know the potential hazards before you start your experiments.

Always wear your lab coat, gloves and face protection and consider this the minimum personal protective equipment when working with biological materials. Never wear contaminated clothing outside of the lab.

Always wash your hands:
• After working with biologically active materials.
• After removing gloves, lab coat, or other contaminated clothing.
• Before leaving the lab.
• Before eating, drinking, applying cosmetics, or smoking.

Never touch your face while doing work with biologically active materials.
Never pipette by mouth.
Never wear Contact lenses.
Never apply cosmetics in a lab.
Never transfer biological liquids at high speed. (this can cause dangerous aerosols)
Always Keep Lab doors shut while working with biological materials.
Always decontaminate the lab at the end of each experiment and immediately after every spill.
Always keep lab notebooks and other hard to sanitize materials away from potential contamination.
8.0 Building Evacuation Plan

In many emergency situations, evacuation will be necessary. Section 1 specifies general evacuation procedures; subsequent sections will detail evacuation for specific situations.

8.1 General Evacuation Procedure

1. Building occupants will be notified of the evacuation by the sound of the building fire alarm, by verbal instruction from building staff or emergency personnel, or by self-evident hazardous conditions.
2. All occupants must leave the building immediately if the fire alarm is activated, or if directed to do so by the Departmental staff.
3. Departmental Staff will oversee and assist the evacuation to the extent possible without endangering further loss of life or themselves.
4. All occupants should exit the building through the nearest safe exit or exit stairwell.
ELEVATORS SHOULD NEVER BE USED IN AN EMERGENCY SITUATION.
5. In Stevenson Center, Building 6 the emergency exits and stairwells are on 1) the main exit on the west side of building – 3rd floor, 2) the north side of the building through the Engineering building, and 3) the west side of the building through the stairwell.
6. If the nearest exit or exit stairwell is blocked by smoke or other hazard proceed to an alternate exit.
7. Once outdoors proceed to the assembly area located outside the southeast corner of Jacobs/Featheringill Hall.
8. Staff members should ensure that proper assistance has been summoned by calling the VUPD at 1-911.
9. Once assembled, the Emergency Coordinators will account for all occupants in order to inform arriving emergency services if anyone is missing or still inside of building.
10. Emergency Coordinators will provide information to arriving emergency personnel concerning the nature of the emergency.
11. Building occupants will not re-enter the building until cleared by VUPD or safety personnel.

8.2 Assisting Impaired Persons During Evacuation

A. Mobility Impaired – Wheelchair
   * If the situation is not urgent, move the person in the wheelchair to a room with an exterior window, a telephone, and a fire-resistant door. Remain with the person, send notification to the assembly area, and contact emergency responders. Wait for assistance from trained personnel.
   * If the situation is urgent, remove the impaired person down the stairway using the “person cradle” or transfer the person to a sturdy office chair. While one helper leans this chair backward, the other faces the chair and holds the front legs of the chair. Both helpers will simultaneously lift the chair and move it down one step, then repeat the process.
B. Hearing Impaired
• If the hearing impaired person does not see a flashing strobe light, alert them to the emergency and evacuation.

C. Visually Impaired

• Prior to evacuation, a “buddy” should be chosen and briefed on assisting the visually impaired person during the emergency.
9.0 Building and Lab Security

If you see anyone you don't know and acting suspicious in any way, CALL SECURITY immediately at 2-2745.

REPORT SUSPICIOUS PERSONS, VEHICLES, OR ACTIVITIES IMMEDIATELY! CALL THE VUPD EMERGENCY LINE AT 1-1911!

Below is a list of telephone numbers to reach the Police Department (Area code is 615):

EMERGENCIES 1-1911 (On-Campus) 421-1911 (Off-Campus)

- Dispatcher/Routine Business 2-2745 (322-2745 Off-Campus)
- Vandy Vans/Escorts 1-8888 (421-8888 Off-Campus)
- Community Relations 2-2558 (322-2558 Off-Campus)
- Criminal Investigations Division 2-2204 (322-2204 Off-Campus)
- Fax 3-7547 (343-7547 Off-Campus)
- Comments/Suggestions 2-2558 (322-2558 Off-Campus)

Here are some other resources:

Counseling/Support/Information:

Crisis Intervention Center 244-7444 [24 hours]

College Hotline 255-LINE (255-5463) [6 p.m. to 2 p.m. daily]

Residential and Judicial Affairs <http://www.vanderbilt.edu/ResEd/> 2-2591

Opportunity Development Center <http://www.vanderbilt.edu/ode/index.htm> 2-4705

Employee Assistance Program <http://www.vanderbilt.edu/HRS/wellness/eap.htm> [Faculty and Staff] 6-1EAP (936-1327)

Psychological and Counseling Center <http://www.vanderbilt.edu/pcc/> 2-2571

Rape and Sexual Abuse Center <http://www.rasac.org/> Crisis Line 256-8526 and 1-800-879-1999 [24 hours]

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YMCA Shelter and Domestic Violence Program 297-8833 [24 hours]

Other Vanderbilt Resources:

Environmental Health and Safety <http://www.safety.vanderbilt.edu/>, 322-2057 and Emergency Pager 835-4965 [24 hours]
10. Appendices

Appendix A: Glossary and Abbreviations

The following microelectronics and nanotechnology terms and health and safety definitions are often encountered in departmental research operations. These definitions are included here to help departmental researchers better understand clean room terminology and the hazardous properties of common chemicals when referring to MSDSs or other references.

Acute Effects: refers to the duration of the symptoms. Acute means symptoms lasting a few hours or days. Again, it has nothing to do with the severity of the effects.

Acute Exposure: as used in toxicology refers to a short-term exposure. This term has nothing to do with either the severity of the exposure or the severity of the effect. The type of exposure occurring during an accidental chemical spill is properly described as an acute exposure.

AHF: Authority Having Jurisdiction over a certain regulation, often refers to the local fire department.

Allergies and Hypersensitivity: reactions by particular individuals to specific chemicals, caused by heredity or prior overexposure. Hypersensitive individuals should avoid any exposure to the offending agents.

Alignment: The positioning of a mask or reticle with respect to the wafer during semiconductor fabrication operations.

Angstrom: A unit of wavelength of light equal to one ten-billionth of a meter.

Anneal: A high temperature processing step (usually the last one), designed to repair defects in the crystal structure of the wafer.

APCVD: Atmospheric Pressure Chemical Vapor Deposition.

Ashing: Process in which photosist is removed from the wafer by heating it and turning it to ash.

Automated Cylinder Valve (ACV): The best form of ESOV, this is a normally closed, pneumatically held open valve assembly that replaces the manual valve on top of the gas cylinder. This safety feature allows for automatic opening and closing of the valve by an automated gas cabinet purge program, and automatic shut down of the gas cylinder in response to detection of a gas leak.

Buffered Oxide Etch: A mix of hydrogen fluoride (HF) and ammonium fluoride (NH4F) used to promote oxide etching at a slow, controlled rate.

Burn-in: Term given to heat soaking components to determine operational reliability at elevated temperatures or temperature fluctuations.

Carcinogen: A substance producing or inciting cancerous growth.

CGA: Compressed Gas Association.

Chip (Die): The slice of silicon on which the tiny devices of the integrated circuit are formed during semiconductor fabrication operations.

Chronic Effects: long-term effects, manifested by prolonged duration and continuing injury.

Chronic Exposure: refers to a long-term exposure. Again, this term has nothing to do with the severity of the exposure, the severity of the consequences, or the duration of the
consequences. Chronic exposures can be the result of chemicals in the workplace, the home or the environment. Chronic exposures are usually the result of carelessness, ignorance, or neglect, and not the result of an accident.

**Closed Room Environment:** An enclosed area where the amount and size of particulate matter in air, temperature, humidity, and pressure are closely controlled.

**CMP:** Chemical Mechanical Polishing—A wafer flattening and polishing process that combines chemical removal with mechanical buffing. Used for polishing/flattening wafers after crystal growing and wafer planarization during the wafer fabrication process.

**CMOS:** Complementary metal oxide semiconductor.

**Combustible Liquids:** Combustible liquids shall mean any liquid having a flash point (closed cup) at or above 100°F and shall be known as Class II or Class III liquids. Class II liquids shall include those having flash points (closed cup) at or above 100°F and below 140°F. Class IIIA liquids shall include those having flash points (closed cup) at or above 140°F and below 200°F. Class IIIB liquids shall include those having flash points (closed cup) at or above 200°F.

**Contact Aligner:** An aligner tool that clamps the wafer and mask into a tight contact before the resist exposure cycle.

**Corrosive Material:** Any liquid or solid that causes visible destruction of human skin tissue or a liquid that has a severe corrosive rate on steel.

**CVD:** Chemical Vapor Deposition.

**Deep Ultraviolet (DUV):** A light wavelength often used to expose photoresist that has the advantage of being able to produce smaller image widths.

**Deionized Water:** Water that has had all charged particles removed. Commonly called “D.I. water,” it is used throughout the entire semiconductor fabrication process.

**Deposition:** The depositing or laying down of various chemicals on wafers, generally done in a high temperature furnace or evaporator.

**Developer:** Chemical used to remove areas defined in the masking and exposure steps of wafer fabrication.

**DIE:** See Chip.

**Diffusion:** The fabrication process whereby high temperature furnaces are used to drive dopant material into the wafer.

**Dopant:** Chemical “impurities” used to regulate the current flow in integrated circuit junctions. Usually put on the wafer via furnaces, implants, or CVD systems and later diffused further into the wafer by heat.

**Dry Etch:** Generally used in place of the wet chemical acid bathing technique to produce more uniform pattern definition, particularly with smaller geometries, as is necessary for smaller critical dimension semiconductor processing.

**Emergency Shut Off Valve (ESOV):** A valve located in the gas piping train, usually close to the cylinder CGA fitting, which can be closed either automatically or manually in response to a gas emergency. For example, automatic closure might result from a signal from the gas monitoring system; manual closure can be done from the gas cabinet EMO button.

**EMO:** “Emergency Machine Off” button located on or next to equipment for emergency power off for all hazardous energies used or generated in a tool.

**EPI—(i.e. epitaxy):** A special process for growing additional layers of silicon on wafers. Usually either silane or silicon tetrachloride is used at a high temperature in a reactor.
Evaporation: The vaporizing of a material such as aluminum or gold and subsequent deposition of the vapor on the wafers.

Exothermic Reaction: A reaction, which produces heat (releases energy).

Expose: In masking after proper alignment of mask to wafer, light is allowed to activate or polymerize the photoresist on the wafer much like exposing film in a camera.

Fab: Fabrication i.e., wafer fabrication clean room area is called fab or "Wafer fab."

Flammable Liquids: Flammable Liquids shall be divided into three classes of liquids as follows: 1.) Class I A - Liquids having flash points below 73°F (23°C) and having a boiling point below 100°F (38°C); 2.) Class I B - Liquid having a flash point below 73°F and having a boiling point above 100°F; and 3.) Class I C - Liquids having flash points (closed cup) at or above 78°F and below 100°F.

Flash Point: Flash point is the temperature at which a liquid has a vapor pressure sufficient to form an ignitable mixture in the air near the surface of the liquid. Open cup flash points vary several degrees higher than closed cup flash point for a specific chemical.

Furnace: Generally refers to high temperature tools used for depositions and diffusions in wafer fabrication. Crystal growing machines are also referred to as furnaces.

Classification: Process used to place an environmentally safe protective coating on the completed semiconductor. This hard surface is the final process completed before the individual chips are cut from the silicon wafers and tested for operational capabilities.

Hard Bake: Generally, in masking, the baking of wafers at about 150°C (302°F) to remove moisture from photoresist and provide for better adhesion of the photoresist after develop and prior to etching.

HF: Hydrofluoric acid -- chemical commonly used in semiconductor manufacturing that is of particular concern because of its tendency to become absorbed by the human body, its insidious effects on bone and because exposure does not always result in immediate pain warning the exposed victim. Exposure to HF requires specialized medical treatment as soon as possible after contact.

BPM—Hazardous Production Material: A solid, liquid or gas that has a degree of hazard ranking in health, flammability or reactivity of 3 or 4 as ranked by NFPA and which is used directly in research, laboratory or production processes that have, as their end product, materials which are not hazardous.

HEPA Filter: High Efficiency Particulate Air Filter capable of filtering out 99.97 percent of particles greater than 0.3 microns in diameter.

IDLH: Immediately Dangerous to Life and Health.

Integrated Circuit (IC): An array of transistors and other components on a piece of semiconductor material.

Junction: The interface at which the conductivity type of a circuit material changes from P-type to N-type or vice versa.

Jungle: Generally, the entire collection of tubes, lines, bubblers, injectors, etc. found at the back end of a diffusion or deposition system. Also called a source cabinet.

Laminar Flow Hoods: The hoods used in clean rooms where it is important to maintain laminar airflow characteristics throughout a given space.

LEL: Lower Explosive Limit; the minimum concentration at which a gas will explode. A common unit of measurement is a percent of the LEL.

LPCVD: Low Pressure Chemical Vapor Deposition. (Furnace).
Mask: A glass plate covered with an array of patterns used on the photo-masking process. Each pattern consists of opaque and clear areas that respectively prevent or allow light to pass. The mask surface may be emulsion, chrome, iron oxide, silicon, or a number of other materials.

Masking: The fabrication process whereby each layer of the process is photographically transposed onto the wafer.

MBE—Molecular Beam Epitaxy: An evaporation rather than a CVD process. An electron beam is directed into the center of the target material, that heats the target to the liquid state. In this state, atoms evaporated out of the material, exit the cell through an opening, and deposit on the wafers. MBE has found production use in the fabrication of special microwave devices and for compound semiconductors such as gallium arsenide.

Micron: Equal to one millionth of a meter. Used in measuring thickness of material or line width at various steps of processing.

Microprocessors: A single semiconductor device that carries out the processing tasks in a digital system. Its development made the microcomputer possible. A microprocessor incorporates both the arithmetic logic unit and the control unit—components previously requiring separate dedicated devices.

Mil: Equal to 0.001 in. (0.03 mm). Used in measuring thickness and width at various steps of processing.

Mini-environment: An environment that maintains wafer cleanliness by storing, transporting, and loading or unloading wafers in small, clean enclosures.

MOCVD—Metal Organic Chemical Vapor Deposition: one of the options for CVD of compound semiconductor materials. A Group III halide (e.g., gallium) is formed in the hot zone and the gallium arsenide compound is deposited in the cold zone. In the metalorganic process for gallium arsenide, trimethylgallium is metered into the reaction chamber along with arsine to form gallium arsenide.

MOS: Metal Oxide Semiconductor.

MSDS: Material Safety Data Sheet: provides key information on chemical characteristics and hazards of a material.

Mutagen: Capable of inducing mutations.

Nanometer: A unit of measure equal to one billionth of a meter.


NIOSH: National Institute of Occupational Safety and Health.

Nitride: (Si3N4) An abbreviation for silicon nitride. This compound material is used to form an insulation layer on a circuit.

Optoelectronics: The technology that combines solid state electronics and optics.

Organometallic Compounds: Organic compounds in which metal atoms have replaced one or more hydrogen atoms. The hazards of these compounds vary, but most of the materials are flammable liquids or solids. Most compounds are very reactive and some will react with air or moisture at room temperature. Examples of some organometallic compounds include trimethylaluminum, diethylzinc, and trimethylgallium.

OSHA: Occupational Safety and Health Administration.

Oxidation: The process which combines oxygen and heat with a silicon wafer in a furnace to produce a layer of silicon dioxide ("oxide").
Oxide: Silicon dioxide. Grown on a wafer, oxide is used as a deterrent to dopant penetration in deposition and diffusion processes. Also used as part of the structure of the circuit or as a final protective layer (glass).

Package: The finished integrated circuit unit that consists of the chip fastened to a frame inside a ceramic or plastic case whose metal leads can be inserted into printed circuit boards.

Passivation: Usually a silicon dioxide or silicon nitride layer put over an existing layer of the wafer to protect against moisture, contamination and abrasion.

Pass-through: An enclosure installed in a wall with a door on each side that allows chemicals, production materials, equipment and parts to be transferred from one side of the clean room wall to the other side.

PECVD: Plasma Enhanced Chemical Vapor Deposition.

PEL: The permissible exposure limit (PEL). Workers may be exposed to these airborne concentration levels for chemicals for up to 8 hours per day, 5 days per week. These values are published by OSHA.

Personal protective equipment (PPE): All equipment used by an individual to protect the respiratory system, eyes, face, head, ears and auditory system, hands, arms, torso, skin, legs and feet from exposure to hazards. PPE commonly includes breathing apparatus, gloves, boots, face shields, suits, and splash or flash protection.

Photoresist: A light-sensitive, frequently flammable liquid that is sprayed on the wafer, exposed and developed to make the circuit image during the wafer fabrication process. This light sensitive photoresist coating is similar to photographic film in an ordinary camera in its sensitivity to light.

Plasma: A high energy gas made up of ionized particles.

Plasma Etcher: A machine in which a high energy RF field excites the gas molecules in the chamber to a high level causing a reaction in which unprotected sections of an oxide layer are removed.

Plasma Etching: An etching process which accomplishes results similar to the chemical etch mechanism reaction using an etching gas instead of a wet chemical.

Poly: Polycrystalline silicon. Usually grown in layers epitaxially to form part of the circuit structure.

Pyrophoric: A substance which ignites spontaneously in air below 130°F (54°C). A chemical with an autoignition temperature in air of less than 13°F.

Reactive Ion Etching (RIE): An etching process that combines plasma and ion beam removal of the surface layer of a wafer. The etchant gas enters the reaction chamber and is ionized. The individual molecules accelerate to the wafer surface. At the surface, the top layer removal is achieved by the physical and chemical removal of the material.

Refile: A miniature reproduction of one layer of a circuit drawing on an emulsion or chrome covered glass plate. Typically 5X or 10X in size it will be reduced and reproduced many times on a mask blank.

RTO (Rapid Thermal Oxidation): An RTP technology used to grow very thin (usually less than 10 Angstroms) MOS gate oxide layers.

RTP (Rapid Thermal Processing): A process usually using high intensity tungsten halogen lamps to heat and cool a wafer in seconds.

SEM -- Scanning Electron Microscope: Tool used in examining portions of circuit by allowing the viewer to see an image as much as 15,000 times its actual size.

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Semiconductor: An element such as silicon or germanium intermediate in electrical conductivity between the conductors and the insulators.
Silane: Common hydride gas used in semiconductor manufacturing; ignites spontaneously in air at a concentration above 3% and will form a flammable mixture in air above 1.4%, if an ignition source is present.
Soft Baking: A heating process used to evaporate a portion of the solvents in resist. The term "soft" describes the still soft resist after baking. The solvents are evaporated to achieve two results: to avoid retention of the solvent in the resist film and to increase the surface adhesion of the resist to the wafer.
Spin: The operation and development in a spinner machine where photoresist or developer is applied to a wafer, while the wafer is rotated at high speed, so that a uniform film coating results.
Sputter: Method of depositing various types of thin metal films on wafers by ion bombardment of a target.
Strip: In semiconductor fabrication operations, refers to the stripping of the photoresist after etch usually in a wet chemical bath or in a plasma chamber.
Substrate: The silicon wafer.
Systemic Effects: Occur throughout the body, or at least away from the point of contact.
Teratogen: A substance causing damage or death to a fetus.
Tetraethylorthosilicate (TEOS): A chemical source for the deposition of silicon dioxide. A combustible liquid (flash point 125°F [52°C]) replacement for silane.
TLV: Threshold Limit Values are developed by the American Conference of Governmental Industrial Hygienists (ACGIH) and refer to airborne concentrations of substances and represent conditions under which it is believed that nearly all workers may be repeatedly exposed day after day without adverse health effects. Due to wide variation in individual chemical susceptibility, a small percentage of workers may experience discomfort from some substances at concentrations at or below the threshold limit.
Tool: Any device, storage container, work station, or process machine used in a semiconductor clean room.
Torr: In vacuum systems the remaining pressure inside the chamber after pump down is a measure of atmospheric pressure expressed in Torr (1 Torr = 1/760 of atmospheric pressure or 1 millimeter of mercury).
VLF: Vertical Laminar Flow.
Wafer: The silicon disc sliced from a crystal on which integrated circuits are manufactured. Also called a substrate or starting material.
Wafer Fab: The area in which circuits are manufactured, usually consisting of masking, diffusion, deposition, and other operations which will transform a polished wafer into hundreds of chips.
Yield: The amount of good usable product as a percentage of the product that started a particular process or step (i.e., on a wafer which has 100 possible chips and 65 are found to be good, then the yield = 65 percent. Or if a "run" of wafers has 50 wafers to start and 41 wafers are finished, the run has a yield of 82 percent).

§1
Appendix B

Chemical Use and Storage Checklist
<table>
<thead>
<tr>
<th>No.</th>
<th>Question</th>
<th>Yes</th>
<th>No</th>
<th>N/A</th>
<th>Comments/Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Are all laboratory surfaces clean and free from removable chemical residue? If it is suspected that a &quot;dirty&quot; looking bench is not contaminated but only stained, the surface should be tested by attempting to clean the staining. If removable staining exists, the lab bench does not meet this criterion.</td>
<td>0</td>
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<tr>
<td>2</td>
<td>Are all fume hoods free from unnecessary storage of chemicals, equipment, containers, etc.? Only equipment and chemicals that are actively being used should be stored in the fume hood if it is a fume hood where chemical work will be done.</td>
<td>0</td>
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<td>3</td>
<td>Are flammable liquids used and stored away from potential ignition sources?</td>
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<td>0</td>
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<tr>
<td>4</td>
<td>Are all hazardous materials stored away from sinks and drains or kept in secondary containment?</td>
<td>0</td>
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<tr>
<td>5</td>
<td>Are signs on storage areas consistent with the hazards within? Cabinets labeled for corrosive storage should be used as such, etc.</td>
<td>0</td>
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<td>6</td>
<td>Are all flammable liquids stored in cabinets that are labeled as being for flammable storage?</td>
<td>0</td>
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<td>7</td>
<td>Are incompatible chemicals segregated according to hazard class including compressed gases?</td>
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<td>8</td>
<td>Are primary and secondary chemical containers 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.</td>
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<td>9</td>
<td>Are peroxide forming ethers (including tetrahydrofuran) dated as to when they were opened?</td>
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<td>Yes</td>
<td>No</td>
<td>N/A</td>
<td>Question</td>
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<td>10. Are all peroxide forming ethers within the six-minute range from when they were opened?</td>
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<td>11. Is the lab free from unnecessary, outdated, or unusable chemicals?</td>
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<td>12. Are corrosive and flammable liquids stored below eye level? These materials should be not stored above the first shelf level on the benches.</td>
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<td>13. Are quantities of flammable liquids stored outside of flammable cabinets kept to a minimum? The total quantity of flammable liquids stored outside of flammable cabinets and/or safety cans should be kept to a minimum and must be less than the lesser of two (2) gallons per square foot of lab space or 150 gallons.</td>
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<td>14. Are all flammable liquid glass containers four (4) liters or smaller?</td>
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<td>15. Is the total quantity of flammable liquids stored in the lab (including that stored in flammable cabinets and/or safety cans) less than the lesser of four (4) gallons per square foot of lab space or 300 gallons?</td>
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<td>16. Are safety cans used to handle flammable liquids properly labeled?</td>
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<td>17. Are non-disposable sharps stored so that the needle is not exposed? Sharp should not be lying on bench tops with the needle exposed. They can be placed in a beaker or other container that protects the needle.</td>
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<td>18. Are unattended reactions labeled with a description of the experiment and contact person? Solvent still should be labeled with the contents of each still.</td>
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<td>Yes</td>
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<td>N/A</td>
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<td>1. Are the names and phone numbers of researchers and emergency contacts posted outside the lab door?</td>
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<td>2. Is the lab properly signed as to the hazards within in the event of an emergency?</td>
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<td>3. Are the exits clearly marked and free from obstruction?</td>
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<td>4. Are the floors dry and free of slip hazards and trip hazards?</td>
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<td>5. Are all aisles and exits free from obstructions so that evacuation is not hindered?</td>
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<td>6. Are fire extinguishers unobstructed, tagged with a current inspection tag, properly pinned, and fully charged?</td>
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<td>7. Are all desk areas free from chemical reagents or evidence of chemical storage?</td>
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<td>8. Is the laboratory free of evidence of food consumption and/or storage, including smoking? Check to make sure no food products or evidence of food products (including used food containers, drink containers, microwaves, ash trays, etc.) are located at laboratory benches, desks, trash cans, refrigerators or any other place in the lab. All refrigerators should be opened and inspected.</td>
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<td>9. Is the laboratory free from clutter and maintained in an orderly fashion, including the bench tops? Chemicals not actively being used should be stored out of the way to minimize spills.</td>
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<td>Yes</td>
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<td>10. Is there a first aid kit available and fully stocked?</td>
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<td>11. Is there an eyewash station and emergency shower nearby and in good condition? Test the eyewash station to make sure it works properly and has proper flow and water temperature.</td>
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<td>12. Are gas cylinders labeled as to their contents and positioned so that the label is clearly visible?</td>
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<td>13. Are gas cylinders stored in a dry, well ventilated area protected from heat sources?</td>
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<td>14. Are gas cylinders properly chained at 2/3 of their height? Check to make sure the chain and structure are sound and that the chain is put on tight.</td>
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<td>15. Are gas cylinders ganged with no more than two (2) cylinders per chain?</td>
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<td>16. Are gas cylinder valves closed and valve caps in place when the cylinders are not in use?</td>
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<td>17. Are empty gas cylinders clearly marked as being empty?</td>
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<td>18. Are gas lines and manifolds clearly marked with the identity of the contents and direction of gas flow?</td>
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<td>19. Are gas cylinders, hoses, tubing, and regulators in good condition? Corrosive, toxic, or flammable gases must be connected with one continuous tube from the regulator to the apparatus.</td>
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<td>20. Is all electrical equipment plugged into an outlet instead of an extension cord?</td>
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<td>21. Are all tools and equipment in good condition and electrically grounded?</td>
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<td>22. Are all physical hazards properly protected? This includes having no exposed belts of gears.</td>
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<td>23. Are all heavy objects (greater than 10 pounds) confined to lower shelves? Objects that due to their size, shape, or weight would require an awkward motion to retrieve them should be stored at chest level or below. Particularly objects that have a reasonable potential to be retrieved should meet this criterion. Exceptions can be made for objects in long term storage.</td>
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<td>24. Are the fume hood flow meters working and not in alarm mode?</td>
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<td>25. Are the fume hood sashes at or below the recommended level?</td>
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<td>26. Are the fume hoods free from obstructions outside of the fume hood that might disrupt the flow of air into the hood?</td>
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</table>
Appendix D

Waste Management Checklist
Vanderbilt University Physics Department Laboratory Inspection Checklist
Laboratory Waste Disposal

Inspection Conducted By (Print Name(s)): ________________________________

Date Of Inspection: ________________________________________________

Principal Investigator/Supervisor: _____________________________________

Room(s) Inspected: _________________________________________________

Signature(s): _____________________________________________________
<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
<th>N/A</th>
<th>Question</th>
<th>Comments/Observations</th>
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<tbody>
<tr>
<td></td>
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<td>1. Is there a designated area to store chemical waste?</td>
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<td>2. Is there a &quot;Hazardous Chemical Waste Area&quot; sign posted near the waste storage area?</td>
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<td>3. Is the waste storage area at or near the point of generation such that waste does not have to be transported across public hallways or rooms or has an exemption been granted by VEH&amp;S?</td>
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<td>4. Are all liquid wastes stored in adequate secondary containment?</td>
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<td>5. Are all waste containers in good condition and free of leaks or residue? The containers and the secondary containment tanks should not have evidence of removable chemical residue.</td>
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<td>6. Are all waste containers properly segregated by compatibility?</td>
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<tr>
<td>Yes</td>
<td>No</td>
<td>N/A</td>
<td>Question</td>
<td>Comments/Observations</td>
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<td>7. Are all waste streams being collected properly?</td>
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<td>8. If the lab works with disposable sharps, is there a sharps disposal container located in the lab? No used, disposable sharps should be in trash cans or on bench tops. Check to see if the sharps container has sharps in it and inquire if the lab is using it.</td>
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<td>9. Are all waste containers properly labeled with VEHS chemical waste tags? This includes disposable sharps containers.</td>
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<td>10. Are all waste containers properly sealed?</td>
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<td>11. Are all sinks labeled with stickers warning against sewer disposal of chemicals?</td>
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<td>12. Are broken glass containers available and being used? Check regular trash receptacles to make sure they do not contain glassware.</td>
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</table>
Appendix E

Personal Safety, Recordkeeping and Training Checklist
Vanderbilt University Physics Department Laboratory Inspection Checklist
Personal Safety, Recordkeeping, & Training

Inspection Conducted By (Print Name[s]):

Date Of Inspection:

Principle Investigator/Supervisor:

Room(s) Inspected:

Signature(s):
<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
<th>N/A</th>
<th>Question</th>
<th>Comments/Observations</th>
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<tbody>
<tr>
<td></td>
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<td></td>
<td>1. Are all laboratory personnel in proper attire? Unacceptable attire includes that which exposes skin below the waist (i.e., shorts, skirts, open-toed shoes)</td>
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<td>2. Are all lab personnel wearing personal protective equipment appropriate for the task being performed? At a minimum, lab personnel working with chemicals must have a lab coat, safety glasses, and gloves. If a reasonable splash potential exists, safety goggles or a face shield must be worn instead of safety glasses.</td>
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<td>3. Does the lab have the appropriate personal protective equipment available for physical hazards such as thermal hazards, abrasion hazards, injection hazards, and laceration hazards?</td>
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<td>4. Does the lab have gloves available suitable for the work done in the lab? For operations involving a high splash potential or potential for hand immersion, non-disposable gloves must be available for use as outer gloves and should be of a length at least to mid forearm. Disposable gloves must be changed if there is any evidence or suspicion of chemical contact or damage to the integrity of the glove and should not be worn for periods longer than 30 minutes and should not be reused once removed.</td>
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<td>5. If the lab is working with chemicals for which disposable nitrile gloves are not suitable, do they have other gloves available? Example chemicals include: * acetic acid, acetone, acrylonitrile, benzene, butyl acetate, chlorobenzene, chloroform, dichloromethane, ethyl benzene, ethyl ether, iodomethane, isonitrile, methyl chloroform, methyl ethyl ketone, methyl iodide, methylene chloride, nitric acid, pyridine, sulfuric acid, toluene, xylene. Note: for incidental contact hazards only, disposable nitrile gloves may be suitable if double gloved.</td>
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<td>6. Does the lab have goggles, face shields, and/or aprons/smocks available for work that involves a high risk of splashing?</td>
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<td>Yes</td>
<td>No</td>
<td>N/A</td>
<td>Question</td>
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<td>7. Are material safety data sheets (MSDS's) available for chemicals stored and used in the lab? The MSDS's must be available as hard copies or as electronic copies stored on a disk or local hard drive. Having access to MSDS's online or through a server is not adequate.</td>
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<td>8. Do lab workers know the location of the MSDS information? Check to see if lab personnel can locate MSDS's for all chemicals present in the lab.</td>
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<td>9. Is there a current chemical inventory available? Check a few chemicals present in the lab to see if they are included in the inventory.</td>
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<td>10. Is there a mechanism to ensure that the inventory is being kept up to date? Inquire about who is in charge of the inventory, how it gets updated relative to chemical usage and ordering, and if there is a mechanism to reconcile the inventory periodically. Check to see if the inventory includes a “last updated” date or other similar tracking information.</td>
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<td>11. Does the lab have an emergency response plan that addresses fires and spills and is the staff trained?</td>
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<td>12. Is the lab staff knowledgeable about what to do in the event of a spill or fire? Make sure the lab personnel have an idea about what type of spill they will clean themselves versus call for outside assistance and that they know what number to call for help.</td>
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<td>13. Is the lab staff knowledgeable about what to do in the event of a chemical exposure? Make sure they know where the eyewash and emergency shower are located and how to use them if exposed (i.e., remove outer contaminated clothing and rinse for at least 15 minutes). Make sure they know where to seek medical help.</td>
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<td>14. Do the lab personnel know how to tell if the hood is working properly and know who to contact if it is not working properly?</td>
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<td>15. Are lab personnel familiar with proper waste storage and disposal policies and procedures?</td>
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<td>16. Does the lab have a “Laboratory Guide for Managing Chemical Waste” available?</td>
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Appendix F:

VEHS Guide for Managing Chemical Wastes
LABORATORY GUIDE FOR MANAGING CHEMICAL WASTE

VANDERBILT UNIVERSITY

Vanderbilt Environmental Health and Safety (VEHS)
322-2057  www.safety.vanderbilt.edu
TABLE OF CONTENTS

CHEMICAL WASTE MANAGEMENT

Identifying Hazardous Waste in Your Lab
Storing Hazardous Waste in Your Laboratory
Disposing of Hazardous Waste
Minimizing Hazardous Waste in Your Laboratory
Highly Hazardous Chemicals and Chemical Spills

SINK/SEWER DISPOSAL

Guide to Laboratory Sink/Sewer Disposal of Wastes
IDENTIFYING HAZARDOUS WASTES IN YOUR LAB

Laboratory personnel should treat all waste chemical solids, liquids, or containerized gases as hazardous wastes unless a specific chemical waste has been confirmed to be non-hazardous by VEHS. A laboratory chemical becomes a "waste" when you no longer intend to use it, regardless of whether or not it has been used or contaminated. Also, spills and absorbent materials used to clean the spill should be disposed of as hazardous waste. Please note that the term "chemical" includes items containing chemicals such as ethidium bromide gels, paints, solvents, degreasers, glues, varnishes, and disinfectants, in addition to stock chemicals and chemical solutions used in laboratory processes.

ADDITIONAL INFORMATION ON THE DEFINITION OF HAZARDOUS WASTE

To ensure consistency with the hazardous waste determination process, laboratories should treat all waste chemicals as hazardous waste and allow VEHS to make the final determination as stated above. However, a more complete description of the hazardous waste determination process is provided here for informational purposes.

Hazardous wastes are defined by the United States Environmental Protection Agency (USEPA) as waste solids, liquids, or containerized gases that meet the definition of a characteristic or listed hazardous waste. Each hazardous waste type is described in detail below.

CHARACTERISTIC HAZARDOUS WASTES

Waste solids, liquids, or containerized gases that exhibit any of the following characteristics are defined as characteristic hazardous wastes: 1) Ignitability; 2) Corrosivity; 3) Reactivity; or 4) Toxicity.

LISTED HAZARDOUS WASTES

The USEPA has already predetermined that certain wastes are hazardous and these hazardous wastes have been incorporated into published lists. The hazardous waste lists are included on the VEHS website.

K-Listed Hazardous Wastes: K-listed hazardous wastes are source-specific wastes that are generated by specific industries such as iron and steel productions facilities. K-listed hazardous wastes are not likely to be found in a laboratory.

F-Listed Hazardous Wastes: F-listed hazardous wastes are non-specific source wastes that are generated by particular industrial processes that can occur in various industries. Industrial processes that generate F-listed hazardous wastes include wood preservation, electroplating and other metal finishing processes, and processes that generate waste solvents.
**Acute Hazardous Wastes**

Certain listed hazardous wastes are considered to be acutely toxic to human health and the environment and are further defined as “acute hazardous wastes.” Acute hazardous wastes include F-, K-, and P-listed hazardous wastes described above.

**Listed Hazardous Wastes in Laboratories**

F-, P-, and U-listed hazardous wastes are the most likely listed hazardous wastes to be found in laboratories. F-listed hazardous wastes may be found in laboratories where electroplating or metal finishing operations are conducted that utilize solutions containing cyanides. Other F-listed wastes that may be found in laboratories include the following solvents or mixtures containing 10 percent or more of the solvent (before use) when spent:

<table>
<thead>
<tr>
<th>Hazardous Waste</th>
<th>Solvent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tetrachloroethylene</td>
<td>Trichloroethylene</td>
</tr>
<tr>
<td>Ortho-dichlorobenzene</td>
<td>Trichlorofluoromethane</td>
</tr>
<tr>
<td>2-nitropropane</td>
<td>Cycliclic acid</td>
</tr>
<tr>
<td>Carbon disulfide</td>
<td>Isobutanol</td>
</tr>
<tr>
<td>Xylene</td>
<td>Acetone</td>
</tr>
<tr>
<td>Methyl isobutyl ketone</td>
<td>n-Butyl alcohol</td>
</tr>
<tr>
<td>1,1,1-trichloroethane</td>
<td>Methylene chloride</td>
</tr>
<tr>
<td>Methylene chloride</td>
<td>Nitrobenzene</td>
</tr>
<tr>
<td>Pyridine</td>
<td>Ethyl acetate</td>
</tr>
<tr>
<td>Cyclohexanone</td>
<td>Toluenene</td>
</tr>
<tr>
<td>1,1,2-trichloroethane</td>
<td>Carbon tetrachloride</td>
</tr>
<tr>
<td>Chlorinated fluorocarbons</td>
<td>Cresols</td>
</tr>
<tr>
<td>Cresols</td>
<td>Methyl ethyl ketone</td>
</tr>
<tr>
<td>Methyl ethyl ketone</td>
<td>2-ethoxyethanol</td>
</tr>
<tr>
<td>Ethyl ether</td>
<td></td>
</tr>
</tbody>
</table>

There are over 300 U-listed hazardous wastes. Please see the VEHS website for the complete list. The U-listed hazardous wastes most commonly found in laboratories include the following:

<table>
<thead>
<tr>
<th>Hazardous Waste</th>
<th>Solvent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetaldehyde</td>
<td>Ethanol</td>
</tr>
<tr>
<td>Acetophenone</td>
<td>Acrylamide</td>
</tr>
<tr>
<td>1-Butanol</td>
<td>Chlorobenzene</td>
</tr>
<tr>
<td>Cyclohexane</td>
<td>Cyclobexamid</td>
</tr>
<tr>
<td>Methylene chloride</td>
<td>2,4-Dichlorophenol</td>
</tr>
<tr>
<td>Trichloroacetic/homomethane</td>
<td>Formaldehyde</td>
</tr>
<tr>
<td>Lead acetate</td>
<td>Mercury</td>
</tr>
<tr>
<td>Methyl ethyl ketone peroxide</td>
<td>Methyl methacrylate</td>
</tr>
<tr>
<td>1,1,1,2-Tetrachloroethane</td>
<td>Thiourea</td>
</tr>
<tr>
<td>Thallium acetate</td>
<td>2-Propanone</td>
</tr>
<tr>
<td></td>
<td>Acrolein</td>
</tr>
<tr>
<td></td>
<td>1,4-Dioxane</td>
</tr>
<tr>
<td></td>
<td>Formic acid</td>
</tr>
<tr>
<td></td>
<td>Methanol</td>
</tr>
<tr>
<td></td>
<td>Tetrachloroethylene</td>
</tr>
<tr>
<td></td>
<td>Toluene</td>
</tr>
<tr>
<td></td>
<td>Acetone</td>
</tr>
<tr>
<td></td>
<td>Acrolein nitrite</td>
</tr>
<tr>
<td></td>
<td>o-Chlorophenol</td>
</tr>
<tr>
<td></td>
<td>Ethylene dichloride</td>
</tr>
<tr>
<td></td>
<td>Ethyl acetate</td>
</tr>
<tr>
<td></td>
<td>Hydrazine</td>
</tr>
<tr>
<td></td>
<td>Methyl ethyl ketone</td>
</tr>
<tr>
<td></td>
<td>Phenol</td>
</tr>
<tr>
<td></td>
<td>Carbon tetrachloride</td>
</tr>
<tr>
<td></td>
<td>Methyl chloroform</td>
</tr>
</tbody>
</table>

There are over 100 P-listed hazardous wastes. Please see the VEHS website for the complete list. The P-listed hazardous wastes most commonly found in laboratories include the following:

<table>
<thead>
<tr>
<th>Hazardous Waste</th>
<th>Solvent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acrolein</td>
<td>Allyl alcohol</td>
</tr>
<tr>
<td>Chloroacetamide</td>
<td>Chloroform</td>
</tr>
<tr>
<td>p-Nitroaniline</td>
<td>Naphthalene</td>
</tr>
<tr>
<td>Thallium oxide</td>
<td>Ammonium vanadate</td>
</tr>
<tr>
<td></td>
<td>Arsenic acid</td>
</tr>
<tr>
<td></td>
<td>Cyanides</td>
</tr>
<tr>
<td></td>
<td>Potassium cyanide</td>
</tr>
<tr>
<td></td>
<td>Vanadium pentoxide</td>
</tr>
<tr>
<td></td>
<td>Brucine</td>
</tr>
<tr>
<td></td>
<td>Dilsoprophylfluorophosphate</td>
</tr>
<tr>
<td></td>
<td>Sodium azide</td>
</tr>
<tr>
<td></td>
<td>Carbon disulfide</td>
</tr>
<tr>
<td></td>
<td>2,4-Dinitrophenol</td>
</tr>
</tbody>
</table>
HAZARDOUS WASTE CONTAINERS

Hazardous waste must be stored in containers (including lids) made of materials that are compatible with the waste. Hazardous waste containers must be in good condition and free of leaks or any residue on the outside of the container. Unacceptable containers include household detergent and food service containers. The best container for your hazardous waste is the original chemical container.

SEALING HAZARDOUS WASTE CONTAINERS

Hazardous waste containers must be sealed to prevent leakage or spillage. Containers should be sealed with a screw-type lid or other appropriate device. Plastic wrap, aluminum foil, and other make-shift lids are unacceptable. A container holding hazardous waste must ALWAYS be closed during storage, except when it is necessary to add or remove waste. If a waste container is used to collect waste from a continuous process (i.e., drainage from a process collected with tubing inserted into a bottle), the container must still be sealed using rubber stoppers with tubing inserts or other appropriate means.

LABELING HAZARDOUS WASTE CONTAINERS

Hazardous waste containers must be labeled with hazardous chemical waste tags provided by VEHS as soon as the container is used to collect hazardous waste, regardless of whether the container is full. These tags require the laboratory to provide specific information including name, telephone number, building, room number, and exact contents of the container. The date should be filled in on the tag when the container is full. It is important to include as much information as is known about the contents of the hazardous waste container, including percentages and water content, to facilitate disposal. If a container is being used to collect hazardous waste intermittently, the tag should be filled out immediately upon use of the container and must be edited as more waste is added. A separate tag must accompany each individual hazardous waste container. Old labels that do not accurately describe the contents of the waste container (i.e., the original label for a toluene bottle now being used to store waste xylene) must be defaced.

MIXING HAZARDOUS WASTES

Hazardous wastes should be kept separate whenever possible. Mixing a hazardous waste with a non-hazardous waste can increase the volume of hazardous waste for disposal. Mixing hazardous wastes with other hazardous wastes can increase disposal costs due to differences in disposal options for certain hazardous wastes. For instance, halogenated solvents such as methylene chloride and chloroform are more costly to dispose of than non-halogenated solvents such as hexane and xylene; therefore, halogenated solvent wastes should be kept separate from non-halogenated solvent wastes.

VEHS Quick Facts:
- Store hazardous waste in sealed, compatible containers.
- Hazardous waste containers must be kept closed at all times except to add waste.
- Label hazardous waste containers with VEHS chemical waste tags as soon as waste accumulation begins.
- Store hazardous wastes with secondary containment.
- Segregate incompatible hazardous wastes.
- Never accumulate more than 55 gallons of hazardous waste or one quart of acute hazardous waste.
HAZARDOUS WASTE CONTAINER STORAGE

You should designate an isolated portion of your laboratory as a hazardous waste storage area. Laboratories with multiple rooms may designate one hazardous waste accumulation area for all rooms as long as hazardous waste will not have to be transported in or across a hallway or through any area that is not controlled by the lab. Hazardous wastes must be stored with secondary containment so that spills cannot reach sink, hood, or floor drains. Incompatible hazardous wastes must be segregated to prevent reaction. Segregation methods include storing in separate cabinets, storing in separate hoods, or storing in separate secondary containment containers such as 5-gallon buckets or tubs. Please refer to your laboratory’s Chemical Hygiene Plan or the VEHS website for guidelines on segregating chemicals by hazard class.

Proper Hazardous Waste Storage: Hazardous waste is labeled, segregated by compatibility, stored in secondary containment, and in an isolated area.

Improper Hazardous Waste Storage: No VEHS labels, no secondary containment, no segregation, and containers are covered with residue.

Improper Hazardous Waste Storage: No secondary containment from hood drain, storage in high traffic area.

Improper Hazardous Waste Storage: No VEHS labels, no secondary containment, and container not sealed properly (open funnel).

HAZARDOUS WASTE STORAGE LIMITS

Your laboratory must NOT store more than 55 gallons of hazardous waste or one quart of acute hazardous waste at one time. You must have your hazardous waste and acute hazardous waste collected at such a frequency to prevent exceeding these limits. If these limits are ever exceeded, you must immediately submit a collection request form to VEHS, as described in the VEHS Environmental Fact Sheet, “Disposing of Hazardous Waste.” Please see the VEHS Environmental Fact Sheet, “Identifying Hazardous Wastes in Your Laboratory” for the definition of acute hazardous waste.

You must also consider your storage capacity when establishing your storage area. Hazardous waste must be stored in a manner to minimize the risk of a spill, stored with secondary containment, and segregated by compatibility. You must not store hazardous waste in quantities that prevent proper storage practices. Based on your laboratory’s rate of generation of hazardous waste, your storage capacity, and keeping in mind the quantity limits described above, you must determine the amount of hazardous waste you will accumulate in your storage area prior to having it collected by VEHS. Laboratories should try to minimize storage of hazardous waste.
HAZARDOUS WASTE COLLECTION PROGRAM

VEHS has implemented a Hazardous Waste Collection Program to collect hazardous waste directly from your laboratory. You must utilize the Hazardous Waste Collection Program to dispose of all hazardous waste generated by your laboratory. There is NO CHARGE for using the Hazardous Waste Collection Program. Hazardous wastes must NOT be transported to the VEHS waste storage facilities by personnel other than VEHS staff members.

LABORATORY DISPOSAL OF WASTES

All hazardous wastes must be disposed of through the VEHS Hazardous Waste Collection Program. Hazardous wastes must NOT be discharged to the sewer via sink drains, hood drains, or other mechanisms.

Hazardous wastes must NOT be disposed of by evaporation – this includes evaporation in fume hoods or biosafety cabinets. Remember, hazardous waste containers must be kept closed at all times except to add or remove waste.

SUBMITTING A WASTE COLLECTION REQUEST FORM

You must submit a Chemical Waste Collection Request Form to have your hazardous waste collected by VEHS. These forms have been designed to provide the VEHS staff with a summary of the type and volume of waste each laboratory is requesting to be collected so that the proper collection equipment will be utilized. Please visit the VEHS website to submit an electronic Chemical Waste Collection Request Form or to print the form to be submitted by fax.

Dating the Hazardous Waste Containers

Hazardous waste containers should be dated when they are filled. This is accomplished by filling in the date on the hazardous chemical waste tag that should be attached to the container. (Please see the VEHS Environmental Fact Sheet, “Storing Hazardous Waste in Your Laboratory” for labeling requirements for hazardous waste.) Full containers should not be stored in the laboratory for excessive periods of time (i.e., have full containers collected within approximately one week).

When to Submit the Collection Request Form

Your laboratory must store hazardous waste according to the guidelines provided in the VEHS Environmental Fact Sheet, “Storing Hazardous Waste in Your Laboratory.” You must have your hazardous waste collected at such a frequency to remain in compliance with those guidelines and so that full containers of hazardous waste are not stored for excessive periods of time as described above.
HAZARDOUS WASTE COLLECTION SCHEDULE

Chemical hazardous wastes are collected on Tuesdays and Thursdays. If you require an emergency collection that cannot wait for a regularly scheduled pickup, please let us know and we will try to accommodate you as quickly as possible. Chemical Waste Collection Request Forms must be received no later than 8:30 a.m. of the scheduled pickup day to be picked up on that day.

DISPOSAL OF HAZARDOUS WASTE CONTAINERS

Acute Hazardous Waste Containers

An empty container that has held an acute hazardous waste must be triple rinsed using a solvent (which might be water) capable of removing the acute hazardous waste prior to disposal of the container as regular trash. Each rinsing should be performed with an amount of solvent equal to approximately 5 percent of the volume of the container. The rinsate must be collected and disposed of as hazardous waste. The containers should be defaced of any chemical or hazardous waste labels and the cap should be removed prior to disposal as regular trash. Please see the VEHS Environmental Fact Sheet, “Identifying Hazardous Waste in Your Laboratory” for a definition of acute hazardous waste.

Other Hazardous Waste Containers

A container that has held any hazardous waste, other than an acute hazardous waste, can be disposed of as regular trash once all the waste has been poured out. The waste should be emptied out leaving as little residue as possible. The containers should be defaced of any chemical or hazardous waste labels and the cap should be removed prior to disposal as regular trash.

TRAINING FOR LABORATORY PERSONNEL

Your laboratory personnel should be trained on the proper handling, storage, labeling, and disposal of hazardous wastes generated by your laboratory. Training should also include procedures for responding to spills or leaks and waste minimization practices. Training should be administered at a frequency sufficient to ensure competency in the proper management practices.
CHEMICAL REDISTRIBUTION
VEHS has implemented a Chemical Redistribution Program to redistribute unwanted, usable chemicals from one laboratory to another instead of disposing of them as hazardous waste. Information on obtaining chemicals from the Program, donating chemicals to the Program, and other information about the Program can be found at the VEHS website.

PRODUCT SUBSTITUTION
Laboratories should attempt to substitute non-hazardous or less toxic materials into their processes and experiments whenever possible. One example is the substitution of biodegradable (non-hazardous) scintillation fluids for hazardous scintillation fluids.

INVENTORY MANAGEMENT AND CONTROL
Laboratories should periodically evaluate their chemical inventory and dispose of unwanted/obsolete chemicals. Purchase only the quantity of chemicals required for specific projects. Vanderbilt University has to pay for the disposal of hazardous wastes. Ordering bulk quantities of chemicals to save money may end up costing more money after disposal of the excess quantity.

PROCESS MODIFICATION
To the extent that it does not affect vital research or teaching, laboratories should modify experiments to decrease the quantity of hazardous chemicals used and generated. Microanalysis techniques can greatly reduce the amount of hazardous waste generated.

SEGREGATION AND CHARACTERIZATION
To the extent possible, do not mix wastes or waste streams. In particular, do not mix non-hazardous waste with hazardous waste. Segregation and characterization allows waste to be redistributed for reuse by another researcher. If the waste cannot be redistributed, segregation minimizes disposal costs.

NEUTRALIZATION AND RECLAMATION
Some laboratories generate a simple, pure chemical stream, such as a dilute acid or base that can be rendered non-hazardous by simple neutralization. Other laboratories may generate a dilute aqueous stream that contains a metal that can be easily precipitated, rendering the waste stream non-hazardous. Additionally, reclamation systems are available for some waste streams such as silver recovery systems for photograph fixer solutions. Strict laws apply to processes for neutralizing hazardous wastes. For these types of waste streams, labs are encouraged to contact VEHS to determine if they can process these materials to render them non-hazardous.

GOOD HOUSEKEEPING PRACTICES
Spilled chemicals and the materials used to clean up the spills must be disposed of as hazardous waste. Good housekeeping practices to minimize the likelihood of a spill can reduce the amount of hazardous waste generated.
HIGHLY HAZARDOUS CHEMICAL WASTES

Certain chemical wastes must be handled by special procedures due to their highly hazardous nature. These chemicals include expired isopropyl and ethyl ethers (these chemicals typically expire 8 months after the container is opened), dry picric acid, and dry 2,4-dinitrophenylhydrazine. These chemicals can explode during opening or routine handling. A comprehensive list of highly hazardous chemicals can be found at the VEHS website. If you encounter these or other highly hazardous waste chemicals in your laboratory, leave them alone and notify VEHS immediately to arrange for disposal. Highly hazardous chemicals must NOT be handled by laboratory personnel.

Expired ether is one of the most common highly hazardous chemicals found in laboratories. Ether is extremely flammable and can form explosive peroxides after exposure to air and light. Since it is packaged in an air atmosphere, peroxides can form even in unopened containers. Therefore, it is very important to write the date received and the date opened on all ether containers. Opened containers should be disposed of through the VEHS Hazardous Waste Collection Program within 6 months. Unopened containers should be disposed of through the VEHS Hazardous Waste Collection Program within one year. Ether 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.

Your laboratory/department will be charged for the disposal of highly hazardous chemicals, since they are not included in the Hazardous Waste Collection Program budget. The charge will be the direct cost charged to VEHS by our disposal contractor. VEHS does not mark up the disposal charges for these chemicals.

HAZARDOUS WASTE SPILLS

Chemical spills must be cleaned up immediately. Spilled chemicals should be treated as hazardous waste. The materials used in the spill cleanup should also be treated as hazardous waste unless the materials can be decontaminated. Chemical spills that cannot be cleaned up by laboratory personnel should immediately be reported to VEHS after evacuating and isolating the spill area.
INTRODUCTION

Vanderbilt University is required to comply with sewer disposal restrictions established by the Metro wastewater treatment plant and all applicable State and Federal regulations. This guide is designed to assist laboratories with the identification of waste streams that are prohibited or limited from sink/sewer disposal. Wastes must NOT be intentionally diluted to comply with sink/sewer disposal requirements. Please note that application of some regulatory requirements to laboratory waste streams is extremely complicated. Contact the Vanderbilt Environmental Health and Safety Department (VEHS) for assistance in applying these guidelines to your specific waste streams. For more information on how to collect and manage hazardous wastes, contact VEHS.

WASTES FORBIDDEN FROM SINK/SEWER DISPOSAL

The following wastes must NEVER be discharged to the sanitary sewer in ANY concentration. These wastes must be collected and managed as hazardous waste.

1. Raw Chemical Waste.
   Unused, pure, or concentrated chemicals.

2. Chlorinated Hydrocarbon Waste.
   Chlorinated hydrocarbons are compounds that contain chlorine, hydrogen, and carbon. Examples of chlorinated hydrocarbons include but are not limited to:
   a. Chloromethanes:
      Specific examples:
      Methylene chloride
      Trichloromethane (chloroform)
      Trichlorofluoromethane
   b. Chloroethanes:
      Specific examples:
      1,1-Dichloroethane
      1,1,1-Trichloroethane
      1,1,2-Trichloroethane
      Hexachloroethane
   c. Chloroethylenes:
      Specific examples:
      Vinyl chloride
      Trichloroethylene
      Tetrachloroethylene
   d. Chloropropanes, chlorobutanes, chlorobutenes:
      Specific examples:
      Dichlorobutadiene
      Hexachlorobutadiene
   e. Chlorinated paraffins.
Guide to Laboratory Sink/Sewer Disposal of Wastes

EPA Compliance Fact Sheet: Revision 1
Vanderbilt Environmental Health and Safety
Telephone: 322-2057   Fax: 343-4951   After hours pager: 835-4965
www.safety.vanderbilt.edu

f. Chlorinated pesticides
   Specific examples:
   
<table>
<thead>
<tr>
<th>Chlorine</th>
<th>Heptachlor epoxide</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aldrin</td>
<td></td>
</tr>
<tr>
<td>Chlor dane</td>
<td>Hexachloride</td>
</tr>
<tr>
<td>DDT</td>
<td>Hexachlorobenzene</td>
</tr>
<tr>
<td>2,4-D</td>
<td>Lindane</td>
</tr>
<tr>
<td>Diazinon</td>
<td>Methoxychlor</td>
</tr>
<tr>
<td>Endrin</td>
<td>Mirex</td>
</tr>
<tr>
<td>Heptachlor</td>
<td>Toxaphene</td>
</tr>
</tbody>
</table>

   g. Nucleo-chlorinated aromatic hydrocarbons
   Specific examples:
   Dichlorobenzene
   Dichlorotoluene
   Chlorobenzene
   1,2-Dichlorobenzene
   1,4-Dichlorobenzene
   Chlorinated biphenyls (including PCBs)
   Chlorinated naphthalenes
   Pentachlorophenol
   2,4,5-Trichlorophenol
   2,4,6-Trichlorophenol

   h. Side-chain chlorinated aromatic hydrocarbons
   Specific examples:
   Chloromethyl benzene (benzyl chloride)
   Dichloromethyl benzene (benzal chloride)
   Trichloromethyl benzene (benzotrichloride).


   Specific examples:
   Bromoform
   Bromomethane

   Includes cyanide, cyanate (OCN⁻), and thiocyanate (SCN⁻) compounds.
   Specific examples:
   Potassium cyanide
   Sodium cyanide
   Hydrogen cyanide
   Zinc cyanide
   Copper cyanide
   Nickel cyanide.
6. **Heavy Metal Waste.**

Specific examples:

<table>
<thead>
<tr>
<th>Element</th>
<th>Metal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antimony</td>
<td>Mercury</td>
</tr>
<tr>
<td>Arsenic</td>
<td>Nickel</td>
</tr>
<tr>
<td>Barium</td>
<td>Selenium</td>
</tr>
<tr>
<td>Cadmium</td>
<td>Silver</td>
</tr>
<tr>
<td>Chromium</td>
<td>Thallium</td>
</tr>
<tr>
<td>Copper</td>
<td>Zinc</td>
</tr>
<tr>
<td>Lead</td>
<td></td>
</tr>
</tbody>
</table>

7. **Corrosive Waste.**

Corrosive wastes are wastes that could cause corrosive structural damage to the sink/sewer piping. All wastes with a pH lower than 5.0 Standard Units (S.U.) or higher than 9.0 S.U. are considered corrosive wastes. Laboratories must not neutralize corrosive wastes to comply with this requirement unless it is part of a written protocol for the laboratory process generating the waste and the neutralization process is carried out by trained, qualified personnel.

8. **Solvent Waste.**

Wastes containing any of the following solvents in any concentration:

<table>
<thead>
<tr>
<th>Solvent</th>
<th>Solvent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetone</td>
<td>Ethyl Ether</td>
</tr>
<tr>
<td>Benzene</td>
<td>Isobutanol</td>
</tr>
<tr>
<td>n-Butyl Alcohol</td>
<td>Methanol</td>
</tr>
<tr>
<td>Carbon Disulfide</td>
<td>Methyl Ethyl Ketone (MEK)</td>
</tr>
<tr>
<td>Carbon Tetrachloride</td>
<td>Methyl Isobutyl Ketone</td>
</tr>
<tr>
<td>Cresols</td>
<td>Nitrobenzene</td>
</tr>
<tr>
<td>Cyclohexanone</td>
<td>2-Nitropropane</td>
</tr>
<tr>
<td>Cresylic Acid</td>
<td>Pyridine</td>
</tr>
<tr>
<td>2-Ethoxyethanol</td>
<td>Toluene</td>
</tr>
<tr>
<td>Ethyl Acetate</td>
<td>Xylene</td>
</tr>
<tr>
<td>Ethyl Benzene</td>
<td></td>
</tr>
</tbody>
</table>

Please note that acetone used to wash glassware falls into this category.

9. **Oil and Grease Wastes.**

Waste oils and grease, including vacuum pump oil, must be collected and managed as hazardous wastes. Wastes that are contaminated with oil or grease in concentrations greater than 50 mg/L must also be collected and managed as hazardous waste.
10. Ignitable Wastes.
   Ignitable wastes are: 1) Liquid wastes with a flashpoint less than 60 °C (140 °F); 2) Non-liquid wastes that are capable of causing fire through friction, reaction with moisture, or spontaneous chemical changes; 3) Ignitable compressed gases; or 4) Oxidizers. Ignitable wastes include most waste solvents found in laboratories, ignitable compressed gases such as hydrogen, and oxidizers such as nitrates/nitrites (sodium nitrate, potassium nitrite, etc.) and chlorates and perchlorates (magnesium perchlorate, etc.). Ignitable wastes include mixtures of ignitable chemicals with other materials if the mixture still exhibits the ignitability characteristic (i.e., flashpoint less than 60 °C).

   Reactive waste: 1) Are normally unstable and readily undergo violent change; 2) React violently or form explosive mixtures with water; 3) Can generate toxic gases, vapors or fumes when mixed with water or exposed to extreme pH conditions; or 4) Are capable of detonation or explosive reaction under certain conditions. Common reactive wastes found in laboratories include certain cyanides, sulfides, and silanes or any mixtures of multiple wastes that exhibit reactivity characteristics.

12. Solid or Viscous Wastes.
   Solid or viscous wastes that may coat, clog, or otherwise cause obstruction to the flow of sewer pipes must never be discharged to the sewer. Examples of prohibited solid or viscous waste include sand, animal tissues, bones, plastics, rubber, glass, wood chips, wood shavings, plaster, paint, etc. in such quantity, concentration, or form that may cause interference with proper sewer flow. Depending on the nature of the waste, it may be discharged to the normal trash or collected and managed as hazardous waste.

   Wastes that may cause a discoloration or that may cause interference in the Metro wastewater treatment plant must not be discharged to the sewer. Wastes that are noxious or nauseous to the extent that a nuisance may be created at the Metro wastewater treatment plant or in other laboratories must not be discharged to the sewer.

   Wastes that contain any element or compound that cannot be adequately treated or removed by the Metro wastewater treatment plant (biological activated sludge treatment) and that is known to be an environmental hazard must not be discharged to the sewer.

15. Hot Liquid or Vapor Wastes.
   Liquid or vapor wastes with a temperature above 65.5 °C (150 °F) must not be discharged to the sewer.

   Buffer solutions and other solutions containing ethidium bromide or acrylamide in any concentration and ethidium bromide and acrylamide gels.
17. Priority Pollutant Wastes.  
All wastes containing any of the following priority pollutant compounds in any concentration must be collected and managed as hazardous waste:

<table>
<thead>
<tr>
<th>Volatiles</th>
<th>Pesticides</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acrylonitrile</td>
<td>Acroclin</td>
</tr>
<tr>
<td>Benzene</td>
<td>Aldrin</td>
</tr>
<tr>
<td>Chlorobenzene</td>
<td>BHC, beta</td>
</tr>
<tr>
<td>Chloroform</td>
<td>BHC, delta</td>
</tr>
<tr>
<td>Dichlorobromomethane</td>
<td>Chloroform</td>
</tr>
<tr>
<td>Dichloroethane</td>
<td>Chlorinated DDT, 4,4'-DDE</td>
</tr>
<tr>
<td>Dichloromethane</td>
<td>Chlorinated DDD, 4,4'-DDE</td>
</tr>
<tr>
<td>Dichlorofluoroethane</td>
<td>Dichlorophosphate, Endosulfan</td>
</tr>
<tr>
<td>1,1-Dichloroethane</td>
<td>Endosulfan sulfate, Endrin</td>
</tr>
<tr>
<td>2,2-Dichloropropane</td>
<td>Endrin, aldrin, Endrin aldrin, 4,4'-DDT</td>
</tr>
<tr>
<td>2,4-Dichlorophenyl ether</td>
<td>Endrin</td>
</tr>
<tr>
<td>Ethylbenzene</td>
<td>Ethylbenzene</td>
</tr>
<tr>
<td>Methyl chloride</td>
<td>Ethylbenzene, Methyl chloride</td>
</tr>
<tr>
<td>1,1,1,1-Tetrachloroethane</td>
<td>Ethylbenzene, Methyl chloride, 1,1,1,1-Tetrachloroethane</td>
</tr>
<tr>
<td>Trans-dichloroethylene</td>
<td>Ethylbenzene, Methyl chloride, 1,1,1,1-Tetrachloroethane</td>
</tr>
<tr>
<td>Trichloroethane</td>
<td>Ethylbenzene, Methyl chloride, 1,1,1,1-Tetrachloroethane</td>
</tr>
<tr>
<td>Trichloroethane</td>
<td>Ethylbenzene, Methyl chloride, 1,1,1,1-Tetrachloroethane</td>
</tr>
<tr>
<td>Trichlorofluoromethane</td>
<td>Ethylbenzene, Methyl chloride, 1,1,1,1-Tetrachloroethane</td>
</tr>
<tr>
<td>Trichloroethane</td>
<td>Ethylbenzene, Methyl chloride, 1,1,1,1-Tetrachloroethane</td>
</tr>
<tr>
<td>Trichloroethane</td>
<td>Ethylbenzene, Methyl chloride, 1,1,1,1-Tetrachloroethane</td>
</tr>
<tr>
<td>Vinyl chloride</td>
<td>Ethylbenzene, Methyl chloride, 1,1,1,1-Tetrachloroethane</td>
</tr>
<tr>
<td>Base/Neutral</td>
<td>Ethylbenzene, Methyl chloride, 1,1,1,1-Tetrachloroethane</td>
</tr>
<tr>
<td>Acenaphthene</td>
<td>Ethylbenzene, Methyl chloride, 1,1,1,1-Tetrachloroethane</td>
</tr>
<tr>
<td>Anthracene</td>
<td>Ethylbenzene, Methyl chloride, 1,1,1,1-Tetrachloroethane</td>
</tr>
<tr>
<td>Benzo(a)anthracene</td>
<td>Ethylbenzene, Methyl chloride, 1,1,1,1-Tetrachloroethane</td>
</tr>
<tr>
<td>Benz(a)pyrene</td>
<td>Ethylbenzene, Methyl chloride, 1,1,1,1-Tetrachloroethane</td>
</tr>
<tr>
<td>Benzo(ghi)perylene</td>
<td>Ethylbenzene, Methyl chloride, 1,1,1,1-Tetrachloroethane</td>
</tr>
<tr>
<td>Benzo(a)anthracene</td>
<td>Ethylbenzene, Methyl chloride, 1,1,1,1-Tetrachloroethane</td>
</tr>
<tr>
<td>Bis(2-chloroethyl)ether</td>
<td>Ethylbenzene, Methyl chloride, 1,1,1,1-Tetrachloroethane</td>
</tr>
<tr>
<td>Bis(2-chloroethyl)ether</td>
<td>Ethylbenzene, Methyl chloride, 1,1,1,1-Tetrachloroethane</td>
</tr>
<tr>
<td>Bis(2-chloroethyl)ether</td>
<td>Ethylbenzene, Methyl chloride, 1,1,1,1-Tetrachloroethane</td>
</tr>
<tr>
<td>4-Chlorophenyl phenyl ether</td>
<td>Ethylbenzene, Methyl chloride, 1,1,1,1-Tetrachloroethane</td>
</tr>
<tr>
<td>4-Chlorophenyl phenyl ether</td>
<td>Ethylbenzene, Methyl chloride, 1,1,1,1-Tetrachloroethane</td>
</tr>
<tr>
<td>Chrysene</td>
<td>Ethylbenzene, Methyl chloride, 1,1,1,1-Tetrachloroethane</td>
</tr>
<tr>
<td>Diphenyl ether</td>
<td>Ethylbenzene, Methyl chloride, 1,1,1,1-Tetrachloroethane</td>
</tr>
<tr>
<td>Di-n-ethyl phthalate</td>
<td>Ethylbenzene, Methyl chloride, 1,1,1,1-Tetrachloroethane</td>
</tr>
<tr>
<td>Dimethyl phthalate</td>
<td>Ethylbenzene, Methyl chloride, 1,1,1,1-Tetrachloroethane</td>
</tr>
<tr>
<td>Di-n-ethyl terephthalate</td>
<td>Ethylbenzene, Methyl chloride, 1,1,1,1-Tetrachloroethane</td>
</tr>
<tr>
<td>Di-n-ethyl terephthalate</td>
<td>Ethylbenzene, Methyl chloride, 1,1,1,1-Tetrachloroethane</td>
</tr>
<tr>
<td>Fluoranthene</td>
<td>Ethylbenzene, Methyl chloride, 1,1,1,1-Tetrachloroethane</td>
</tr>
<tr>
<td>Flamazone</td>
<td>Ethylbenzene, Methyl chloride, 1,1,1,1-Tetrachloroethane</td>
</tr>
<tr>
<td>Hexachlorobenzene</td>
<td>Ethylbenzene, Methyl chloride, 1,1,1,1-Tetrachloroethane</td>
</tr>
<tr>
<td>Hexachlorocyclopentadiene</td>
<td>Ethylbenzene, Methyl chloride, 1,1,1,1-Tetrachloroethane</td>
</tr>
<tr>
<td>Hexachloroethane</td>
<td>Ethylbenzene, Methyl chloride, 1,1,1,1-Tetrachloroethane</td>
</tr>
<tr>
<td>Indeno(1,2,3-cd)pyrene</td>
<td>Ethylbenzene, Methyl chloride, 1,1,1,1-Tetrachloroethane</td>
</tr>
<tr>
<td>N,N-dimethyl 2-aminoethylamine</td>
<td>Ethylbenzene, Methyl chloride, 1,1,1,1-Tetrachloroethane</td>
</tr>
<tr>
<td>N,N-dimethylpropylamine</td>
<td>Ethylbenzene, Methyl chloride, 1,1,1,1-Tetrachloroethane</td>
</tr>
<tr>
<td>Phenanthrene</td>
<td>Ethylbenzene, Methyl chloride, 1,1,1,1-Tetrachloroethane</td>
</tr>
<tr>
<td>Pyrene</td>
<td>Ethylbenzene, Methyl chloride, 1,1,1,1-Tetrachloroethane</td>
</tr>
<tr>
<td>1,2,4-Trichlorobenzene</td>
<td>Ethylbenzene, Methyl chloride, 1,1,1,1-Tetrachloroethane</td>
</tr>
</tbody>
</table>

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18. Rinseate.
Empty containers that are being rinsed should be triple rinsed with a minimal amount of liquid and the rinseate collected and managed as hazardous waste, if the container held any of the wastes described above in Sections 1, 2, 3, 4, 5, 6, or 8. Subsequent rinses may be discharged to the sewer. Depending on the waste, fewer rinses may be required to be collected. Contact VEHS for evaluation of specific waste containers. Rinseate from empty containers that held other types of waste may be discharged to the sewer if the rinseate does not exhibit the hazardous characteristic of the waste (for example, rinseate from a container that held ignitable waste may be sewer disposed if the rinseate is not ignitable).

WASTES WITH LIMITED SINK/SEWER DISPOSAL

1. Radioactive Wastes.
   A radioactive waste that is water soluble or readily dispersible in water and not prohibited from sewer disposal based on the criteria described in the previous section may be disposed via the sanitary sewer system. The disposal limit is 200 μCi per laboratory per day. Records of sewer disposal must be maintained on the Radioactive Material Usage Log.

2. Biological Materials.
   Biological waste must not be discharged to the sewer unless it has been properly treated. Please refer to Proper Disposal of Biological Waste in the Guide to Bioremediation at Vanderbilt for biological waste disposal policies and procedures (VEHS website). Biological waste intended for sewer disposal must not be prohibited from sewer disposal based on the criteria described in the previous section.

   Organic chemicals suitable for sink/sewer disposal are described below. Only those organic compounds that are reasonably soluble in water are suitable for sink/sewer disposal. A compound is considered water soluble if it dissolves to the extent of at least three percent. Chemicals listed below must be in concentrations of approximately one percent or less to be suitable for sink/sewer disposal. If the total volume of waste to be disposed is greater than four liters per day, approval by VEHS is required. Sewer discharges of these chemicals must not be prohibited in the previous
section. Any chemicals that fall into categories described below but are specifically prohibited from sink/sewer disposal in the previous section must NOT be discharged to the sewer.

a. Alkanols with 4 or fewer carbon atoms.
   Specific examples:
   
<table>
<thead>
<tr>
<th>2-Butanol</th>
<th>2-Propanol</th>
<th>Tert-butanol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethanol</td>
<td>1-Propanol</td>
<td></td>
</tr>
</tbody>
</table>

b. Alkanediols with 7 or fewer carbon atoms.
   Specific examples:
   
<table>
<thead>
<tr>
<th>Butanediol and isomers</th>
<th>Butylene glycol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethylene glycol</td>
<td>Heptamethylene glycol</td>
</tr>
<tr>
<td>Heptanediol and isomers</td>
<td>Hexanediol and isomers</td>
</tr>
<tr>
<td>Hexylene glycol</td>
<td>Pentanediol and isomers</td>
</tr>
<tr>
<td>Pentylene glycol</td>
<td>Propylene glycol</td>
</tr>
</tbody>
</table>

c. Sugars and sugar alcohols (polyols).
   Specific examples:
   
<table>
<thead>
<tr>
<th>Dithiocerythritol</th>
<th>Dithiothreitol</th>
<th>Erythritol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glycerol</td>
<td>Lacitol</td>
<td>Maltitol</td>
</tr>
<tr>
<td>Mannitol</td>
<td>Melasaxes</td>
<td>Sorbitol</td>
</tr>
<tr>
<td>Xylitol</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

d. Alkoxyalkanols with 6 or fewer carbon atoms.
   Specific examples:
   | Butoxyethanol    | Ethoxyethanol  | Methoxyethanol |

   | Acetaldehyde     | Butyraldehyde (butanal) |
   | Formaldehyde     | Glutaraldehyde     |
   | Isobutyraldehyde | Propionaldehyde (propanal) |
f. RCONH₂ and RCONHR with 4 or fewer carbon atoms and RCONR₂ with 10 or fewer carbon atoms.
Specific examples:

<table>
<thead>
<tr>
<th>Acetamide</th>
<th>Butanamide</th>
</tr>
</thead>
<tbody>
<tr>
<td>Butyramide</td>
<td>Formamide</td>
</tr>
<tr>
<td>Isobutyramide</td>
<td>N,N-Diethyl formamide</td>
</tr>
<tr>
<td>N,N-Dimethyl acetamide</td>
<td>N,N-Dimethyl propionamide</td>
</tr>
<tr>
<td>N-Ethyl acetamide</td>
<td>N-Ethyl formamide</td>
</tr>
<tr>
<td>N-Methyl acetamide</td>
<td>N-Methyl formamide</td>
</tr>
<tr>
<td>N-Methyl propionamide</td>
<td>Propionamide</td>
</tr>
</tbody>
</table>

g. Aliphatic amines with 6 or fewer carbon atoms.
Specific examples:

<table>
<thead>
<tr>
<th>Amylamine</th>
<th>Isoamylamine</th>
<th>Butylamine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimethylpropylamine</td>
<td>Ethylamine</td>
<td>1-Ethylpropylamine</td>
</tr>
<tr>
<td>Hexylamine</td>
<td>Isobutyramide</td>
<td>Isopropylamine</td>
</tr>
<tr>
<td>Methylamine</td>
<td>Methylbutylamine</td>
<td>N-Ethylbutylamine</td>
</tr>
<tr>
<td>N-Ethylmethylamine</td>
<td>N-Methylpropylamine</td>
<td>Trimethylamine</td>
</tr>
<tr>
<td>Iso-amylamine</td>
<td>Diethylamine</td>
<td></td>
</tr>
</tbody>
</table>

h. Aliphatic diamines with 6 or fewer carbon atoms.
Specific examples:

<table>
<thead>
<tr>
<th>Ethylene diamine</th>
<th>Hexamethylene diamine and isomers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pentamethylenediamine and isomers</td>
<td>Piperazine</td>
</tr>
<tr>
<td>1,2-Propanediamine</td>
<td>1,3-Propanediamine</td>
</tr>
<tr>
<td>Triethylenediamine</td>
<td></td>
</tr>
</tbody>
</table>

i. Alkanic acids with 5 or fewer carbon atoms and the ammonium, sodium, and potassium salts of these acids with 20 or fewer carbon atoms.
Specific examples:

<table>
<thead>
<tr>
<th>Acetic acid</th>
<th>Butyric acid</th>
<th>Formic acid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isobutyric acid</td>
<td>Isovaleric acid</td>
<td>Propionie acid</td>
</tr>
<tr>
<td>Valeric acid</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
j. Alkanedioic acids with 5 or fewer carbon atoms and the ammonium, sodium, and potassium salts of these acids with 20 or fewer carbon atoms.
   Specific examples:
   - Fumaric acid
   - Malic acid
   - Oxalic acid (1,2-ethanedic acid)
   - Tartaric acid
   - Glutaric acid (1,5-pentanedioic acid)
   - Maleic acid (1,3-propanedioic acid)
   - Succinic acid (1,4-butanedioic acid)

k. Hydroxyalkanoic acids with 5 or fewer carbon atoms and the ammonium, sodium, and potassium salts of these acids with 20 or fewer carbon atoms.
   Specific examples:
   - Glycolic acid
   - 1-Hydroxybutyric acid
   - 2-Hydroxyisobutyric acid
   - Lactic acid (2-hydroxypropanoic acid)

l. Aminoolkanic acids with 6 or fewer carbon atoms and the ammonium, sodium, and potassium salts of these acids with 20 or fewer carbon atoms.
   Specific examples:
   - 3-Amino butyric acid
   - Amino isobutyric acid
   - 3-Amino pentanoic acid and isomers

m. Esters with 4 or fewer carbon atoms.
   Specific examples:
   - Ethyl formate
   - Isopropyl acetaet
   - Methyl formate
   - Methyl propionate
   - Isopropyl formate
   - Propyl formate
   - Methyl acetate

n. Nitriles.
   Specific examples:
   - Acetonitrile
   - Butyronitrile
   - Isobutylnitrile
   - Propionitrile
o. Sulfonic acids and sodium and potassium salts of the acids.
Specific examples:

<table>
<thead>
<tr>
<th>Methane sulfonic acid</th>
<th>Ethane sulfonic acid</th>
</tr>
</thead>
<tbody>
<tr>
<td>I-Propane sulfonic acid</td>
<td>1-Butane sulfonic acid</td>
</tr>
<tr>
<td>I-Pentane sulfonic acid</td>
<td>1-Hexane sulfonic acid</td>
</tr>
<tr>
<td>I-Heptane sulfonic acid</td>
<td>1-Octane sulfonic acid</td>
</tr>
<tr>
<td>I-Decane sulfonic acid</td>
<td>1-Dodecane sulfonic acid</td>
</tr>
<tr>
<td>I-Tetradecane sulfonic acid</td>
<td>1-Hexadecane sulfonic acid</td>
</tr>
</tbody>
</table>

4. Specific Inorganic Chemicals in Concentrations of One Percent or Less.
Inorganic chemicals suitable for sink/sewer disposal are described below. Only those inorganic compounds that are reasonably soluble in water are suitable for sink/sewer disposal. A compound is considered water soluble if it dissolves to the extent of at least three percent. Chemicals listed below must be in concentrations of approximately one percent or less to be suitable for sink/sewer disposal. If the total volume of waste to be disposed is greater than four liters per day, approval by VEHS is required. Sewer discharges of these chemicals must not be prohibited in the previous section. Any chemicals that fall into categories described below but are specifically prohibited from sink/sewer disposal in the previous section must NOT be discharged to the sewer.

a. Inorganic salts for which both the cations and anions are listed in the following table.

```
<table>
<thead>
<tr>
<th>Cations</th>
<th>Anions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum, Al⁺³</td>
<td>Borate, BO₃⁻³, H₂BO₂⁻</td>
</tr>
<tr>
<td>Ammonium, NH⁺²</td>
<td>Bromide, Br⁻</td>
</tr>
<tr>
<td>Calcium, Ca⁺²</td>
<td>Carbonate, CO₃⁻²</td>
</tr>
<tr>
<td>Cesium, Cs⁺</td>
<td>Chloride, Cl⁻</td>
</tr>
<tr>
<td>Hydrogen, H⁺</td>
<td>Blufite, HSO₄⁻</td>
</tr>
<tr>
<td>Lithium, Li⁺</td>
<td>Hydroxide, OH⁻</td>
</tr>
<tr>
<td>Magnesium, Mg⁺²</td>
<td>Oxide, O₂⁻</td>
</tr>
<tr>
<td>Potassium, K⁺</td>
<td>Iodide, I⁻</td>
</tr>
<tr>
<td>Sodium, Na⁺</td>
<td>Nitrate, NO₃⁻</td>
</tr>
<tr>
<td>Stearate, Sr⁺⁺</td>
<td>Phosphate, PO₄⁻³</td>
</tr>
<tr>
<td>Tin, Sn⁺⁴</td>
<td>Sulfate, SO₄²⁻</td>
</tr>
<tr>
<td>Titanium, Ti⁺⁴, Ti⁺⁶</td>
<td></td>
</tr>
<tr>
<td>Zirconium, Zr⁺⁶</td>
<td></td>
</tr>
</tbody>
</table>
```
REFERENCES

2. Metropolitan Government of Nashville and Davidson County Code of Laws Title 15.60.
The following chemicals must not be discharged to the sanitary sewer in any concentration. This list contains examples of specific chemicals and does NOT include all chemicals that are forbidden from sewer disposal. For more information on whether a chemical not listed below can be discharged to the sewer, refer to the detailed sections in this guide or contact VEHS.

<table>
<thead>
<tr>
<th>Specific Chemicals Forbidden from Sewer Disposal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acenaphthene</td>
</tr>
<tr>
<td>Acetone</td>
</tr>
<tr>
<td>Acrylamide</td>
</tr>
<tr>
<td>Aldrin</td>
</tr>
<tr>
<td>Antimony</td>
</tr>
<tr>
<td>Asbestos</td>
</tr>
<tr>
<td>Benzo(a)anthracene</td>
</tr>
<tr>
<td>Benzo(a)pyrene</td>
</tr>
<tr>
<td>Benzo(b)fluoranthene</td>
</tr>
<tr>
<td>3,4-Benzo(a)pyrene</td>
</tr>
<tr>
<td>Beryllium</td>
</tr>
<tr>
<td>BHC, beta</td>
</tr>
<tr>
<td>Bis(2-ethylhexyl)phthalate</td>
</tr>
<tr>
<td>Bis(2-chloroethoxy)ethane</td>
</tr>
<tr>
<td>Bis(2-chloroisopropyl)ether</td>
</tr>
<tr>
<td>Bromoform</td>
</tr>
<tr>
<td>Bromomethane</td>
</tr>
<tr>
<td>Butylbenzyl phthalate</td>
</tr>
<tr>
<td>Carbon Disulfide</td>
</tr>
<tr>
<td>Chlorodane</td>
</tr>
<tr>
<td>Chlorinated biphenyls (including PCBs)</td>
</tr>
<tr>
<td>Chlorobenzene</td>
</tr>
<tr>
<td>Chloroethane</td>
</tr>
<tr>
<td>Chloromethyl benzene (benzyl chloride)</td>
</tr>
<tr>
<td>2-Chlorophenol</td>
</tr>
<tr>
<td>Chromium</td>
</tr>
<tr>
<td>Copper</td>
</tr>
<tr>
<td>Cresols</td>
</tr>
<tr>
<td>Cyanide</td>
</tr>
<tr>
<td>2,4-D</td>
</tr>
<tr>
<td>4,4'-DDD</td>
</tr>
<tr>
<td>4,4'-DDE</td>
</tr>
<tr>
<td>Dichlorobenzene</td>
</tr>
<tr>
<td>1,3-Dichlorobenzene</td>
</tr>
</tbody>
</table>
### Specific Chemicals Forbidden from Sewer Disposal

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>3,3'-Dichlorobenzidine</td>
<td>Dichlorobromomethane</td>
</tr>
<tr>
<td>Dichlorobutadiene</td>
<td>Dichlorodi fluoromethane</td>
</tr>
<tr>
<td>1,1-Dichloroethane</td>
<td>1,2-Dichloroethane</td>
</tr>
<tr>
<td>1,1-Dichloroethylene</td>
<td>1,2-Trans-dichloroethylene</td>
</tr>
<tr>
<td>Dichloromethane</td>
<td>Dichloromethyl benzene (benzal chloride)</td>
</tr>
<tr>
<td>2,4-Dichlorophene</td>
<td>1,2-Dichloropropene</td>
</tr>
<tr>
<td>1,2-Dichloropropylene</td>
<td>1,3-Dichloropropylene</td>
</tr>
<tr>
<td>2,4-Dichloropropylene</td>
<td>Dichlorotoluene</td>
</tr>
<tr>
<td>Di-n-n-butyl phthalate</td>
<td>Di-n-butyl phthalate</td>
</tr>
<tr>
<td>Di-n-n-octyl phthalate</td>
<td>4,6-Dinitro-o-cresol</td>
</tr>
<tr>
<td>2,6-Dinitrotoluene</td>
<td>1,2-Diphenylhydrazine</td>
</tr>
<tr>
<td>Endosulfan sulfate</td>
<td>Endosulfan, alpha</td>
</tr>
<tr>
<td>Endosulfan, beta</td>
<td>Endrin</td>
</tr>
<tr>
<td>Endrin alticide</td>
<td>Ethidium Bromide</td>
</tr>
<tr>
<td>2-Ethoxyethanol</td>
<td>Ethyl Acetate</td>
</tr>
<tr>
<td>Ethyl Benzene</td>
<td>Ethyl Ether</td>
</tr>
<tr>
<td>Ethylbenzene</td>
<td>Fluorene</td>
</tr>
<tr>
<td>Fluoranthene</td>
<td>Heptachlor</td>
</tr>
<tr>
<td>Heptachlor epoxide</td>
<td>Hexachloride</td>
</tr>
<tr>
<td>Hexachlorobenzene</td>
<td>Hexachlorobutadiene</td>
</tr>
<tr>
<td>Hexachlorocyclopentadiene</td>
<td>Hexachloroethane</td>
</tr>
<tr>
<td>Hydrogen cyanide</td>
<td>Indeno[1,2,3-cd]pyrene</td>
</tr>
<tr>
<td>Isobutanol</td>
<td>Isophorone</td>
</tr>
<tr>
<td>Lead</td>
<td>Lin dane</td>
</tr>
<tr>
<td>Mercury</td>
<td>Methyl bromide</td>
</tr>
<tr>
<td>Methoxychlor</td>
<td>Methyl benzyl chloride</td>
</tr>
<tr>
<td>Methyl chloride</td>
<td>Methyl Ethyl Ketone (MEK)</td>
</tr>
<tr>
<td>Methyl Isobutyl Ketone</td>
<td>Methylcyclohexyl chloride</td>
</tr>
<tr>
<td>Minox</td>
<td>Naphthalene</td>
</tr>
<tr>
<td>n-Butyl Alcohol</td>
<td>Nickel</td>
</tr>
<tr>
<td>Nickel cyanide</td>
<td>Nitrobenzene</td>
</tr>
<tr>
<td>2-Nitrophenol</td>
<td>4-Nitrophenol</td>
</tr>
<tr>
<td>2-Nitropropane</td>
<td>N-nitrosodimethylaniline</td>
</tr>
<tr>
<td>N-nitrosodi-n-propylamine</td>
<td>N-nitrosodiphenylamine</td>
</tr>
<tr>
<td>PCB-1016</td>
<td>PCB-1221</td>
</tr>
<tr>
<td>PCB-1232</td>
<td>PCB-1242</td>
</tr>
<tr>
<td>PCB-1245</td>
<td>PCB-1254</td>
</tr>
<tr>
<td>PCB-1260</td>
<td>P-chloro-m-cresol</td>
</tr>
<tr>
<td>Chemicals Forbidden from Sewer Disposal</td>
<td></td>
</tr>
<tr>
<td>----------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Pentachlorophenol</td>
<td>Phenanthrene</td>
</tr>
<tr>
<td>Phenols</td>
<td>Potassium cyanide</td>
</tr>
<tr>
<td>Pyrene</td>
<td>Pyridine</td>
</tr>
<tr>
<td>Selenium</td>
<td>Silver</td>
</tr>
<tr>
<td>Sodium cyanide</td>
<td>TCDD (Dioxin)</td>
</tr>
<tr>
<td>1,1,2,1-Tetrafluoroethane</td>
<td>1,1,2,2-Tetrafluoroethane</td>
</tr>
<tr>
<td>Tetrachloroethylene</td>
<td>Tetrachloromethane</td>
</tr>
<tr>
<td>Thallium</td>
<td>Toluene</td>
</tr>
<tr>
<td>Tetrachloroethylene</td>
<td>Tris-dichloroethylene</td>
</tr>
<tr>
<td>1,2,4-Trichlorobenzene</td>
<td>1,1,1-Trichloroethane</td>
</tr>
<tr>
<td>1,1,2-Trichloroethane</td>
<td>Trichloroethylene</td>
</tr>
<tr>
<td>Trichlorofluoromethane</td>
<td>Trichloromethane (chloroform)</td>
</tr>
<tr>
<td>Trichloromethyl benzene (benzotrichloride)</td>
<td>2,4,5-Trichlorophenol</td>
</tr>
<tr>
<td>2,4,6-Trichlorophenol</td>
<td>Vinyl chloride</td>
</tr>
<tr>
<td>Xylene</td>
<td>Zinc</td>
</tr>
<tr>
<td>Zinc cyanide</td>
<td></td>
</tr>
</tbody>
</table>
SUMMARY OF SPECIFIC CHEMICALS WITH LIMITED SEWER DISPOSAL

The following chemicals may be discharged to the sewer in concentrations of approximately one percent or less. If the percentage is greater than one percent, approval by VEHS is required. If the total volume of waste to be disposed is greater than four liters per day, approval by VEHS is required. Sewer discharges of these chemicals must not be prohibited for any other reason. Specifically, solutions containing these chemicals must not also contain chemicals specifically forbidden from sewer disposal. This list contains examples of specific chemicals and does NOT include all chemicals with limited discharge to the sewer. For more information on whether a chemical not listed below can be discharged to the sewer, refer to the detailed sections in this guide or contact VEHS.

<table>
<thead>
<tr>
<th>Specific Chemicals with Limited Sewer Disposal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetaldehyde</td>
</tr>
<tr>
<td>Acetic acid</td>
</tr>
<tr>
<td>3-Amino butyric acid</td>
</tr>
<tr>
<td>Amino isobutyric acid</td>
</tr>
<tr>
<td>3-Amino propanoic acid</td>
</tr>
<tr>
<td>Butanamide</td>
</tr>
<tr>
<td>1-Butane sulfonic acid</td>
</tr>
<tr>
<td>Butoxyethanol</td>
</tr>
<tr>
<td>Butylene glycol</td>
</tr>
<tr>
<td>Butyramide</td>
</tr>
<tr>
<td>Butyronitrile</td>
</tr>
<tr>
<td>Diethylamine</td>
</tr>
<tr>
<td>Dimethyl sulfoxide (DMSO)</td>
</tr>
<tr>
<td>Dithiothreitol</td>
</tr>
<tr>
<td>Erythritol</td>
</tr>
<tr>
<td>Ethanol</td>
</tr>
<tr>
<td>Ethyl formate</td>
</tr>
<tr>
<td>Ethylene diamine</td>
</tr>
<tr>
<td>1-Ethylpropylamine</td>
</tr>
<tr>
<td>Formamide</td>
</tr>
<tr>
<td>Fumaric acid</td>
</tr>
<tr>
<td>Glutaric acid (1,5-pentanedioic acid)</td>
</tr>
<tr>
<td>Glycolic acid</td>
</tr>
<tr>
<td>Heptanediol and isomers</td>
</tr>
<tr>
<td>1-Hexadecane sulfonic acid</td>
</tr>
<tr>
<td>1-Hexane sulfonic acid</td>
</tr>
<tr>
<td>Hexylamine</td>
</tr>
<tr>
<td>3-Hydroxybutyric acid</td>
</tr>
<tr>
<td>Iso-amylamine</td>
</tr>
<tr>
<td>Isobutylamine</td>
</tr>
<tr>
<td>Isobutyraldehyde</td>
</tr>
</tbody>
</table>
### Specific Chemicals with Limited Sewer Disposal

<table>
<thead>
<tr>
<th>Chemical Name</th>
<th>Disposal Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isobutyric acid</td>
<td>Isopropyl acetate</td>
</tr>
<tr>
<td>Isopropyl formate</td>
<td>Isopropylamine</td>
</tr>
<tr>
<td>Isovaleric acid</td>
<td>Lactic acid (2-hydroxypropanoic acid)</td>
</tr>
<tr>
<td>Lactitol</td>
<td>Malic acid</td>
</tr>
<tr>
<td>Malonic acid (1,3-propanedioic acid)</td>
<td>Maltitol</td>
</tr>
<tr>
<td>Mannitol</td>
<td>Methane sulfonic acid</td>
</tr>
<tr>
<td>Methoxyethanol</td>
<td>Methyl acetate</td>
</tr>
<tr>
<td>Methyl formate</td>
<td>Methyl propionate</td>
</tr>
<tr>
<td>Methylamine</td>
<td>Methylbutylamine</td>
</tr>
<tr>
<td>Molasses</td>
<td>N,N-Diethyl formamide</td>
</tr>
<tr>
<td>N,N-Dimethyl acetamide</td>
<td>N,N-Dimethyl propionamide</td>
</tr>
<tr>
<td>N-Ethyl acetamide</td>
<td>N-Ethyl formamide</td>
</tr>
<tr>
<td>N-Ethylbutylamine</td>
<td>N-Ethylmethylamine</td>
</tr>
<tr>
<td>N-Methyl acetamide</td>
<td>N-Methyl formamide</td>
</tr>
<tr>
<td>N-Methyl propionamide</td>
<td>N-Methylpropylamine</td>
</tr>
<tr>
<td>1-Octane sulfonic acid</td>
<td>Oxalic acid (1,2-ethanedioic acid)</td>
</tr>
<tr>
<td>Pentamethylenediamine and isomers</td>
<td>Pentanediol and isomers</td>
</tr>
<tr>
<td>1-Pentane sulfonic acid</td>
<td>Pentylene glycol</td>
</tr>
<tr>
<td>Piperazine</td>
<td>1,2-Propanediamine</td>
</tr>
<tr>
<td>1,3-Propanediamine</td>
<td>1-Propane sulfonic acid</td>
</tr>
<tr>
<td>1-Propanol</td>
<td>2-Propanol</td>
</tr>
<tr>
<td>Propionaldehyde (propanal)</td>
<td>Propionamide</td>
</tr>
<tr>
<td>Propionic acid</td>
<td>Propionitrile</td>
</tr>
<tr>
<td>Propyl formate</td>
<td>Propylene glycol</td>
</tr>
<tr>
<td>Sorbitol</td>
<td>Succinic acid (1,4-butanedioic acid)</td>
</tr>
<tr>
<td>Tartaric acid</td>
<td>Tert-butanol</td>
</tr>
<tr>
<td>1-Tetradecane sulfonic acid</td>
<td>Triethylenediamine</td>
</tr>
<tr>
<td>Trimethylamine</td>
<td>Valeric acid</td>
</tr>
<tr>
<td>Xylitol</td>
<td></td>
</tr>
</tbody>
</table>
Inorganic salts for which both the cations and anions are listed in the following table.

<table>
<thead>
<tr>
<th>Cations</th>
<th>Anions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum, Al$^{3+}$</td>
<td>Borate, BO$_3^{3-}$, B$_4$O$_7^{2-}$</td>
</tr>
<tr>
<td>Ammonium, NH$^{4+}$</td>
<td>Bromide, Br$^-$</td>
</tr>
<tr>
<td>Calcium, Ca$^{2+}$</td>
<td>Carbonate, CO$_3^{2-}$</td>
</tr>
<tr>
<td>Cesium, Cs$^+$</td>
<td>Chloride, Cl$^-$</td>
</tr>
<tr>
<td>Hydrogen, H$^+$</td>
<td>Bisulfite, HSO$_3^-$</td>
</tr>
<tr>
<td>Lithium, Li$^+$</td>
<td>Hydroxide, OH$^-$</td>
</tr>
<tr>
<td>Magnesium, Mg$^{2+}$</td>
<td>Oxide, O$_2^-$</td>
</tr>
<tr>
<td>Potassium, K$^+$</td>
<td>Iodide, I$^-$</td>
</tr>
<tr>
<td>Sodium, Na$^+$</td>
<td>Nitrate, NO$_3^-$</td>
</tr>
<tr>
<td>Strontium, Sr$^{2+}$</td>
<td>Phosphate, PO$_4^{3-}$</td>
</tr>
<tr>
<td>Tin, Sn$^{2+}$</td>
<td>Sulfate, SO$_4^{2-}$</td>
</tr>
<tr>
<td>Titanium, Ti$^{3+}$, Ti$^{4+}$</td>
<td></td>
</tr>
<tr>
<td>Zirconium, Zr$^{3+}$</td>
<td></td>
</tr>
</tbody>
</table>
Appendix G

VEHS Guide for Safety in the Chemical Laboratory
Appendix G

VEHS Guide for Safety in the Chemical Laboratory
Safety in the Chemical Laboratory

A Vanderbilt Safety Reference Manual

Vanderbilt Environmental Health & Safety
U-0211 MCN, 2665
Phone: 322-2057
www.safety.vanderbilt.edu
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Hazard Communication, The Lab Standard & The Chemical Hygiene Plan

The Hazard Communication Standard, also known as the Right to Know Law is mandated by the Occupational Safety & Health Administration (OSHA) in 29 CFR 1910.1200 and by the Tennessee Division of Occupational Safety & Health (TOSHA) in 0800-1-9. This standard requires that all employees (1) receive initial safety training about all hazardous chemicals at work and additional training whenever new hazardous chemicals are introduced, (2) have immediate access to and know how to use Material Safety Data Sheets (MSDS) and (3) are taught to label all containers of chemicals. The Hazard Communication mandated by TOSHA differs from OSHA in that TOSHA also requires annual retraining on hazardous chemicals.

Because of the special safety concerns that arise in a laboratory setting, OSHA developed the Lab Standard (29 CFR 1910.1450). The Lab Standard supplements the requirements of the Hazard Communication Standard by instituting these additional requirements:

- Each lab must have a written Chemical Hygiene Plan.
- The employer must maintain employee chemical exposures below the legal limits.
- Respiratory protection must be provided to maintain chemical exposure below the legal limits.
- The employer must provide free medical consultations and/or examinations if there is a suspected exposure.
- The employer must maintain records for chemical monitoring results, employee medical evaluations, and employee training.

The Chemical Hygiene Plan that is required by the Lab Standard must be specific for each lab and must provide a detailed chemical hygiene plan that outlines policies & procedures used to protect the laboratory workers. Material Safety Data Sheets must be immediately available in all laboratories.

Hazardous Chemicals

Chemicals may be classified as hazardous for several reasons. A chemical may cause injury or damage because of its toxic properties or because of some physical property. For instance, flammable chemicals are hazardous because they will catch fire and burn more readily than other chemicals and a chemical that is a poison causes an adverse health effect on some organ or organ system.

Chemicals That Can Cause Injury

Explosive Chemicals

Some chemicals are explosive and peroxide-forming chemicals can become explosive over time. The first time a container of a peroxide-forming chemical is opened, it must be labeled with the date. These chemicals should be turned over as hazardous waste to VEHS no later than six months from the date they have been opened. If you find a bottle of a peroxide forming chemical and you are not sure how old it is, DO NOT move it if there are white crystals present around on the container. Common examples of some peroxide forming chemicals include ethers, tetrahydrofuran, dioxane & dry picric acid. However, many other chemicals can also form peroxides.
Flammable Chemicals

Flammable chemicals will readily catch fire and burn in air. The most common flammable chemicals found in the laboratory are organic solvents. These chemicals must be stored in a flammable storage cabinet.

Corrosive Chemicals

Corrosive chemicals destroy exposed tissue through chemical action. The most common corrosive chemicals are acids (pH<7) and bases (pH>7). Acids and bases must be stored separately in cabinets that will not be corroded. Hydrofluoric acid is an especially hazardous acid, because it will not only corrode living tissue, it will also damage bone. Individuals who work with hydrofluoric acid must have the antidote, calcium gluconate, immediately available in case of an accident.

Cryogenic Liquids

Cryogenic liquids kill skin through flash freezing – frostbite. Since most cryogenic liquids also displace oxygen as they evaporate, they are hazardous in poorly ventilated areas.

Chemicals That Can Cause Adverse Health Effects

Acute health effects occur immediately after exposure to a toxic chemical. An example of an acute health effect would be passing out after inhalation of a toxin. Chronic health effects may not be evident until days, months, or even years after the exposure and may result from either one exposure or several exposures over a period of time. Emphysema and cancer are two examples of chronic health effects.

Highly/Acutely Toxic Chemicals

Highly or acutely toxic chemicals include any chemical that falls within any of the following OSHA defined categories:
- A chemical with a median lethal dose (LD50) of 50 mg or less per kg of body weight when administered orally to certain test populations.
- A chemical with an LD50 of 200 mg less per kg of body weight when administered by continuous contact for 24 hours to certain test populations.
- A chemical with a median lethal concentration (LC50) in air of 200 parts per million (ppm) by volume or less of gas or vapor, or 2 mg per liter or less of mist, fume, or dust, when administered to certain test populations by continuous inhalation for one hour, provided such concentration and/or condition are likely to be encountered by humans when the chemical is used in any reasonably foreseeable.

Toxins & Select Agent Toxins

Toxins are chemicals created by plants, animals or microorganisms that are poisonous to humans. Certain toxins have been listed as Select Agent Toxins by the Centers for Disease Control (CDC). Vanderbilt is required to register these toxins with the CDC and must follow strict procedures for receipt, use, security and disposal. If you plan to use a Select Agent Toxin, contact the Biosafety Program Manager in the VEH$ department. Following is a list of the Select Agent Toxins:

- Abrin
- Aflatoxins
- Botulinum toxins
- Clostridium perfringens epsilon toxin
- Conotoxins
- Diacetoxyscirpenol
- Shigatoxin
- Staphylococcal enterotoxins
- Tetrodotoxin
- T-2 toxin
- Ricin
- Saxitoxin
Carcinogens

A carcinogen is a substance capable of causing cancer. There are three sources that provide lists of carcinogens:

- These carcinogens have been specifically listed by OSHA in Subpart Z of the OSHA standards:

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Chemical Abstracts (CAS) Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-Nitrobinapthyl</td>
<td>92933</td>
</tr>
<tr>
<td>alpha-Naphthylamine</td>
<td>134-32-7</td>
</tr>
<tr>
<td>methyl chloromethyl ether</td>
<td>107302</td>
</tr>
<tr>
<td>3,3'-Dichlorobenzidine (and its salts)</td>
<td>91-94-1</td>
</tr>
<tr>
<td>bis-Chloromethyl ether</td>
<td>542881</td>
</tr>
<tr>
<td>beta-Naphthylamine</td>
<td>91-59-8</td>
</tr>
<tr>
<td>Benzidine</td>
<td>92-87-5</td>
</tr>
<tr>
<td>4-Aminodiphenyl</td>
<td>92-67-1</td>
</tr>
<tr>
<td>Ethyleneimine</td>
<td>151564</td>
</tr>
<tr>
<td>beta-Propiolactone</td>
<td>57-57-8</td>
</tr>
<tr>
<td>2-Acetylaminofluorene</td>
<td>53963</td>
</tr>
<tr>
<td>4-Dimethylaminoazo-benezene</td>
<td>60117</td>
</tr>
<tr>
<td>N-Nitrosodimethylamine</td>
<td>62-75-9</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td>75-01-4</td>
</tr>
<tr>
<td>Inorganic Arsenic</td>
<td>7440-38-2</td>
</tr>
<tr>
<td>Cadmium</td>
<td>7440-43-9</td>
</tr>
<tr>
<td>Benzene</td>
<td>71-43-2</td>
</tr>
<tr>
<td>1,2-Dibromo-3-chloropropane</td>
<td>96-12-8</td>
</tr>
<tr>
<td>Acrylonitrile</td>
<td>107-13-1</td>
</tr>
<tr>
<td>Ethylene oxide</td>
<td>75-21-8</td>
</tr>
<tr>
<td>Formaldehyde</td>
<td>50-00-0</td>
</tr>
<tr>
<td>Methyleneedianiline</td>
<td>101-77-9</td>
</tr>
<tr>
<td>1,3-Butadiene</td>
<td>106-99-0</td>
</tr>
<tr>
<td>Methylene chloride</td>
<td>75-09-2</td>
</tr>
</tbody>
</table>

- The National Toxicology Program (NTP) lists chemicals under the category "known to be carcinogens" in the Annual Report of Carcinogens (http://ntp-server.niehs.nih.gov/).
- The International Agency for Research on Cancer (IARC) has divided chemicals into different groups (http://193.51.164.11/monoeval/grlist.html):
  - Group 1 lists chemicals that are known to be carcinogenic to humans.
  - Group 2A lists chemicals that are probably carcinogenic to humans.
  - Group 2B lists chemicals that are possibly carcinogenic to humans.

Reproductive Toxins

"A large number of workplace chemicals, physical and biologic agents can damage the reproductive systems of both male and female workers, resulting in infertility, spontaneous abortion, developmental impairment or death in an embryo, fetus or child."
- OSHA Priority Summary Sheet on Reproductive Toxins (http://www.osha.gov/oshinfo/priorities/reproductive.html)
Reproductive toxins are chemicals that can cause problems with male and/or female reproduction. These problems can include fertility and gestation. Some chemicals cause problems for infants if a breast-feeding mother is exposed.

*Mutagens* are chemicals that cause a mutation in DNA. If the mutation occurs in germinal cells, it may affect progeny. *Teratogens* are chemicals that cause birth defects to occur in a developing embryo or fetus when the mother is exposed during pregnancy.

**Chemical Sensitizers (Allergens)**

An *allergy* develops when the immune system reacts to a harmless substance as if it were infectious, triggering the production of antibodies. Subsequent exposures to even very small amounts of the same substance can trigger the allergic response. The individual who has developed an allergy can manifest the allergic response as a skin rash, eye irritation, allergic asthma, or, in severe allergic reactions, anaphylactic shock that can result in death if not treated quickly enough.

There are several chemicals and classes of chemicals that can be sensitizers. Listed here are some of the more common sensitizer chemicals:

- Polyisocyanates
- Latex rubber
- Metals
- Acid anhydrides
- Formaldehyde
- Toluene
- Thioacetic acid
- Diazomethane
- Dicyclohexylcarbodiimide
- Benzylic & allylic halides
- Some phenol derivatives
- Coal tar volatiles

**Chemical Storage**

Chemicals should be stored so that they are separated from other chemicals with which they might react. Use the flammable, acid or base storage cabinets as appropriate.

Be careful to store temperature sensitive chemicals in appropriate refrigerators or freezers. Standard refrigerators are not appropriate for storing volatile and/or flammable chemicals. Use explosion-proof refrigerators for storing flammable chemicals.

Do not store chemicals near direct sunlight or other heat sources and avoid storing chemicals on benches, high cabinets and in chemical hoods.

Provide secondary containment for all liquids when storing or transporting chemicals.
Material Safety Data Sheets (MSDS)

A Material Safety Data Sheet is a detailed report about a chemical or chemical formulation. The report includes a description of the hazards associated with the chemical and how to safely handle it. MSDS's from different manufacturers may have different formats, but they are all required to have the same information. Information that must be included on an MSDS includes:

- Chemical Product & Company Information
- Information on Ingredients
- Hazards Identification
- First Aid Measures
- Fire Fighting Measures
- Accidental Release Measures
- Handling & Storage
- Exposure Controls & Personal Protection
- Physical & Chemical Properties
- Stability & Reactivity
- Toxicological Information
- Ecological Information
- Disposal Considerations
- Transport Information
- Regulatory Information

Some of the terms used in MSDS's may be unfamiliar. On the "Links" page of the VEHS website are links to sites with definitions for many of those terms (http://www.safety.vanderbilt.edu/).

Where to get MSDS's

1. All manufacturers are required to supply MSDS's for the chemicals they sell. If for some reason you do not receive a MSDS for a chemical you have purchased, you can contact the company and ask them to fax the MSDS to you. Several companies now provide online access to their MSDS's.

2. VEHS provides access to an online MSDS service that can be accessed by anyone who is logged on to a VU or VUMC computer (http://www.safety.vanderbilt.edu/).

3. VEHS also provides links to several free online MSDS sites through the "Links" page which can be accessed through any computer with internet access.

Where to keep MSDS's

All laboratories are required to have immediate access to MSDS's for every chemical used or stored in that lab. Therefore, you must keep your MSDS's in a location that is convenient for everyone in your lab.

Container Labeling

The Lab Standard requires that all chemicals be labeled. If you transfer a chemical from the original container to a new container, you need to also label that new container with the name of the chemical. This is very important because in the event of an emergency you need to know the exact chemical name or chemical formulation you are working with so that you will know which MSDS to consult. Containers must be labeled with:

- Chemical name
- Manufacturer's name
- Health hazards
- Physical hazards
- Long & short term health effects

For frequently used chemicals, you can create your own labels for secondary containers using a word processing program and standard labels so that you can print them out as they are needed.
Hazard Warning Signs

NFPA

The National Fire Protection Association (NFPA) labeling system uses a color-coded diamond to represent four different hazards. *Red* indicates fire hazard, *yellow* indicates reactivity hazard, *blue* indicates health hazard, and *white* is used to indicate other hazards such as *W* (water reactive) or *OXY* (oxidizer). Numbers are used to rank the degree for each type of hazard:

4 = extreme hazard  
3 = serious hazard  
2 = moderate hazard  
1 = slight hazard  
0 = no or minimal hazard

The Vanderbilt Laboratory Hazard Sign

Vanderbilt has developed a chemical inventory/signage program called *Hazard Identification Program (HIP)*. On-campus users can access this program through [http://safetyapps.vanderbilt.edu/](http://safetyapps.vanderbilt.edu/).
Personal Protective Equipment, Safety Equipment & Hygiene

Routes of Exposure

The type of Personal Protective Equipment and Safety Equipment you will need depends on the potential routes of exposure for the chemicals you will be working with. There are four ways which chemicals can enter your body: *inhalation, ingestion, absorption and injection.* For our purposes, the *injection* route of entry includes not only an actual injury to the skin caused by a sharp, but also through a pre-existing injury to the skin or through a cut injury (injection) that breaks the skin during a procedure.

Eye & Face Splash protection

To prevent contamination from getting into eyes, goggles are the best choice. Safety glasses do not provide a seal around the eyes and can therefore allow droplets to fall into your eyes. Face shields are also an excellent choice for protecting the entire face from splash contamination. If you should also need eye protection from impact (such as from flying pieces of metal from a grinder or saw) or from radiation (such as from a laser), make sure the safety glass you choose are appropriate and rated for that type of eye protection.

Skin protection

In addition to the clothes and shoes we wear all the time, we need to wear additional protective clothing such as lab coats, lab aprons or chemical resistant protective suits and chemically resistant gloves to prevent contamination of our skin. Most of the time you will not be wearing a protective suit, so avoid wearing clothes that leave large areas of skin bare, such as shorts and sandals, when you plan to work in the lab.

The skin on our hands is the most likely part of our bodies to become contaminated. When selecting gloves for use in the lab remember the following:

1. Not all gloves protect from all chemicals. You will need to make sure that the chemicals you will be handling will not degrade the gloves you plan to wear. Glove manufacturers can provide assistance in determining which gloves will work for different chemicals. **Never wear latex gloves when handling solvents.**
2. Disposable gloves should not be worn all day long. Change gloves frequently.
3. Sometimes you may need to wear more than one pair of gloves; for instance, wear heavy gloves over Nitrile gloves when using large quantities of hazardous chemicals such as halogenated solvents.

For assistance in determining the best PPE to wear for the chemicals you use, consult the NIOSH Guide to Chemical Protective Clothing ([http://www.cdc.gov/niosh/nccpc1.html](http://www.cdc.gov/niosh/nccpc1.html)). There are additional PPE guides available through the VEHS “Links” page under “Chemical Safety.”

To reduce the likelihood of skin contamination in your laboratory, keep your lab clean. Do not leave behind chemical residues that will allow other people to become contaminated.
**Ingestion Protection**

To prevent accidental ingestion of chemicals:
1. Wear gloves during procedures involving chemicals.
2. Wash your hands after each procedure.
3. Never store food or beverages in the lab with chemicals.
4. Never eat or drink in the lab.

**Inhalation Protection**

To prevent inhalation of chemical gases, vapors, dusts or aerosols:
1. Work in a fume hood. The fume hood is your preferred engineering control defense against inhalation uptake of chemicals. Make sure the fume hood is working well before use and work at least six inches in from the edge of the hood to maximize the capture efficiency of your fume hood.
2. Glove boxes are another way to prevent hazardous chemicals exposure.
3. Wearing a respirator is the very last option to consider when providing inhalation protection.
   a. Before anyone can be approved to wear a respirator, they must satisfy these two OSHA requirements: (1) An annual medical evaluation to determine whether or not a person is physically capable of wearing a respirator and (2) OSHA requires a fit-test evaluation to ensure that the respirator seals properly around the face and does not allow unfiltered air to leak in.
   b. Respirator filters are chemical specific. You must make sure that the cartridges in your respirator will absorb the chemical(s) you are planning on working with.

**Emergency Showers & Eye Wash Stations**

If there is an accident, two of the most important pieces of safety equipment you have are the emergency shower and the eye wash station. If you contaminate yourself over a large part of your body or over a part of your body that you cannot rinse off in the sink, immediately go to the emergency shower, strip off any contaminated clothing, and stay under the water for at least 15 minutes. If something splashes into your eye, immediately flush with water for as long as possible. The general rule is to flush with water for 15 minutes.
Fire & Life Safety

Classes of Fire Extinguishers

The class of a fire extinguisher tells you what type of fire that the extinguisher can be used on.

A – fires involving ordinary combustibles such as wood, paper or cloth.
B – fires involving liquids, greases & gases
C – fires involving energized electrical equipment
D – fires involving metals such as Mg, Na or K.

If an extinguisher is rated for multiple classes, it will work on all of the fire classes that are listed. For instance, class “ABC” fire extinguishers work for any type of fire except metal fires.

Using a Fire Extinguisher – PASS

To use a fire extinguisher, remember the acronym PASS:

Pull the pin.
Aim at the base of the fire.
Squeeze the handle.
Sweep back and forth.

When using a fire extinguisher, always start 8-10 feet away from the fire and walk towards the fire as you spray it with the extinguisher. If you start too close, you can actually spread the fire. If the fire is not out by the time you get to the fire, leave; the fire is too big for you to handle. Never attempt to put out a fire that is larger than a small trash can fire.

If there is a fire – RACE

Rescue or Remove everyone in the lab.
Activate the nearest alarm pull station.
Confine the fire by closing lab doors. If it is a hood fire, you should lower the sash, if possible.
Evacuate – Leave lights on, follow the exit signs, stay low in smoky areas and use stairs, not elevators.

Flammable & Combustible Liquid Storage

Flammable liquids should always be stored in Underwriter Laboratories (UL) listed flammable storage cabinets and containers. Only keep small quantities (no more than 5 gallons) of combustibles in ordinary containers outside of flammable storage containers.

Open Flames

If you perform procedures involving open flames, never leave the fire unattended.

Electrical Safety

Keep electrical equipment away from damp areas, such as sinks. Use ground fault protection and arrange equipment to avoid spills. Remember that extension cords are only for short-term use. For long-term power supply, have additional outlets installed.
Compressed Gas & Cryogenic Liquid Cylinder Safety

Compressed Gas & Cryogenic Liquid Cylinders Can Become Rockets

All compressed gases and liquids, even if non-flammable and non-toxic are still potentially hazardous due to oxygen displacement and because it is under high pressure. If a cylinder is not secured properly and falls over, there is a rocket launched in your lab.

Cylinder Transportation & Storage

Use carts only when transporting and never for storage.

Always keep cylinders secured to prevent them from falling. Only secure cylinders to structural supports that are permanently affixed to the floor, wall or ceiling. It is permissible to store up to three capped cylinders together, but secure cylinders individually if they are uncapped.

Store cylinders away from potential heat sources such as incubators, water baths, hot plates or burners.

Never use or store cylinders in poorly ventilated rooms, because compressed gases and liquids can rapidly displace the oxygen in the room, leaving you vulnerable to suffocation. Conversely, oxygen cylinders that are opened in a poorly ventilated room can quickly enrich the atmosphere, creating an atmosphere where the smallest spark could easily start an explosive and deadly fire.

An additional concern when storing cryogenic liquid cylinders in a small, inadequately ventilated area is that water will condense on the floor of the room resulting in a dangerous, slippery floor.

Hazardous Gases

Hazardous gases include both toxic gases and gases that create fire hazards. Hazardous gases must be stored in vented cabinets, fume hoods, or specially designed vented equipment. Store fuel cylinders in vented cabinets, separately from oxygen cylinders.

Following is an incomplete listing of some of the hazardous gases you may use: \( \text{O}_2, \text{H}_2\text{S}, \text{NH}_3, \text{NO}_2, \text{NO}, \text{HCl}, \text{HF}, \text{SO}_2, \text{H}_2, \text{acetylene} \) and halogen gases (\( \text{Cl}_2, \text{Br}_2, \text{F}_2 \)).

Cylinder Safety Tips

Before using a cylinder, verify that you have the correct gas or liquid. When installing cylinders, leak test around valve connections.

When a cylinder is empty, close the valve, check if for leaks, and remove the cylinder. Securely recap the cylinder and attach a tag or sticker that will identify the cylinder as empty.

Choose piping and fittings appropriate for the chemical and the pressures used. When designing piping layout, consider ways to minimize the likelihood of damage to the piping. Do not use adaptors and use only appropriate, compatible regulators.
Spills & Emergency Response

There is no precise definition for what makes a spill "small" or "large." This is because the degree of hazard and toxicity among different chemicals greatly varies. In general, a "small" spill is one that you can safely handle yourself and a "large" spill is one that you cannot safely handle without assistance. If you have any doubts as to whether or not you can handle a spill yourself, then classify it as a "large" spill and call for help.

To respond to a small spill:

1. Evacuate anyone in immediate danger. Take care of injured people before cleaning up the spill.
2. Stop the spread of the spill as soon as possible. Use appropriate absorbent material to contain the spill.
3. Consult the Material Safety Data Sheet (MSDS) for proper decontamination procedures.
4. Call VEHS at 2-2057 or 835-4965 for guidance and if you have any doubts about your ability to safely clean up the spill.

To respond to a large spill:

1. Evacuate anyone in immediate danger.
2. Tell others in your lab to leave the area with you. Close the door after the last person has exited the room. Advise people in neighboring laboratories if there are potential hazards (such as evaporating solvents or hazardous gases) that could endanger them.
3. Phone 1-1911 and 835-4965 to report the situation. Be prepared to tell emergency responders what chemical(s) are involved in the spill.

Personnel Exposures

If a person is contaminated with a chemical, seconds can make a huge difference in the severity of injury. Make sure you know exactly where the nearest emergency showers and eye wash stations are located. Strip contaminated clothing off of the victim and have them rinse the contaminated area for at least fifteen minutes.

In case of a medical emergency, seek medical care from the VUH Emergency Department. Call for an ambulance to transport the victim if necessary.

For non-emergency conditions involving exposure to a chemical during normal business hours, call the Occupational Health Clinic at 936-0955.

All employees who work with hazardous materials will have the opportunity to receive medical attention and any follow up exams under the following circumstances:

- After a spill, leak, or explosion resulting in the likelihood of a hazardous material exposure.
- Whenever an employee develops symptoms associated with exposure to hazardous materials.
- Whenever exposure monitoring reveals an exposure level routinely above the Permissible Exposure Level (PEL) for an OSHA regulated substance.
Contact VEHS

If you have additional questions, assistance and advice about laboratory safety, contact VEHS by phone (322-2057) or emergency pager (835-4965). You can also consult the VEHS web site (http://www.safety.vanderbilt.edu/) for additional safety information.
Appendix I: Student Lab Safety and Training Checklist

Name:

Department:

Advisor/Supervisor:

I have completed and/or read the following required safety training requirements:

<table>
<thead>
<tr>
<th>Title</th>
<th>Date Completed</th>
</tr>
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<tbody>
<tr>
<td>Physical and Chemical Lab Safety (Presentation)</td>
<td></td>
</tr>
<tr>
<td>Hazard Communication (Online)</td>
<td></td>
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<tr>
<td>Vanderbilt Chemical Hygiene Plan (PDF)</td>
<td></td>
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<tr>
<td>Safety and Environmental Protection (PDF)</td>
<td></td>
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<tr>
<td>Laboratory Guide for Managing Chemical Wastes (PDF)</td>
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</tbody>
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I have completed and/or read the following lab specific training requirements:

- Laser Safety Training (Online)
- X-ray Safety (Presentation)
- Accelerator Training (Presentation)
- Instrument Specific Training (Principle Investigator)

Signatures:

- Individual Name, Date
- Supervisor Name/Date
- Department Chair/Date
Appendix J: Important Phone Numbers

EMERGENCY (Police, Fire, Ambulance) 321-1911

VEHS Office 322-2057

- Chemical Waste Pickup
- Chemical Spill Response
- Chemical Safety Information

VEHS Pager 835-4965

VINSE Pager 402-7879

Vanderbilt University Hospital Emergency Room 322-3391

Poison Control Center 936-2934

Occupational Health 936-0955
Appendix C

General Laboratory Safety Checklist