IUPUI
CHEMICAL HYGIENE PLAN

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OCCUPATIONAL EXPOSURES TO
HAZARDOUS CHEMICALS IN LABORATORIES
(29 CFR 1910.1450)
CHEMICAL HYGIENE PLAN

1.0 INTRODUCTION

1.1 OSHA Regulations

On January 31, 1990, the Occupational Safety and Health Administration (OSHA) promulgated a final rule entitled Occupational Exposures to Hazardous Chemicals in Laboratories (commonly known as "The Laboratory Standard" - see Appendix A). The basis for this standard is a determination that laboratories differ from industrial operations in their use and handling of hazardous chemicals and that a different approach than that found in OSHA's substance specific health standards is warranted to protect workers. This standard does not establish new exposure limits, but sets other performance provisions designed to protect laboratory workers from potential hazards in their work environment.

1.2 Purpose

The purpose of this model Chemical Hygiene Plan is to define work practices and procedures to help ensure that Laboratory Workers at IUPUI are protected from health and safety hazards associated with the hazardous chemicals with which they work.

1.3 Applicability

The Laboratory Standard applies to all employees engaged in the laboratory use of hazardous chemicals. Laboratory use of hazardous chemicals is defined as the use or handling of chemicals in which all of the following conditions are met:

- Chemical manipulations are carried out on a "laboratory scale". Laboratory scale is defined as work with substances in which the containers used for reactions, transfers, and other handling of substances are designed to be easily and safely manipulated by one person. This definition excludes those workplaces whose function is to produce commercial quantities of materials.

- Multiple chemical procedures or chemicals are used.

- The procedures involved are not part of a production process, nor in any way simulate a production process.

This standard does not apply to:

- Uses of hazardous chemicals which do not meet the definition of laboratory use, and in such cases, the employer shall comply with the relevant standard in 29 CFR part 1910, subpart Z, even if such use occurs in a laboratory.

- Laboratory uses of hazardous chemicals which provide no potential for employee exposure.

Where the standard does apply, it shall supersede, for laboratories, the requirements of all other OSHA health standards in 20 CFR part 1910, subpart Z, except as follows:

- For any OSHA health standard, only the requirement to limit employee exposure to the specific permissible exposure limit shall apply for laboratories, unless that particular standard states otherwise or unless the action level (or in the absence of an action level, the PEL) is routinely exceeded. - See Appendix B.

- Prohibition of eye and skin contact where specified by any OSHA health standard shall be observed.

Where the action level (or in the absence of an action level, the PEL) is routinely exceeded for an OSHA regulated substance with exposure monitoring and medical surveillance requirements, the employee exposure monitoring and medical monitoring requirements of this standard shall apply.

Any substance specific standard can require coverage to remain under that standard rather than under the laboratory standard. In the absence of a statement of preemption in a substance specific standard, the determination of whether the laboratory standard applies must be dependent on both "laboratory use" and "laboratory scale" criteria. Where these criteria are met, the laboratory standard applies.

1.4 Chemical Hygiene Plan Coverage

The Chemical Hygiene Plan is the written program that contains policies and procedures for the safe use of hazardous chemicals. Major components of the plan include:

- Employee information and training

- Hazard identification
- Personal exposure monitoring
- Medical surveillance
- Standard operating procedures
- Personal protective equipment
- Containment and engineering controls

1.5 Definitions

ACGIH American Conference of Governmental Industrial Hygienists.

Action level A concentration designated in [the OSHA (29 CFR) Laboratory Standard for a specific substance, calculated as an eight-hour time-weighted average, which initiates certain required activities such as exposure monitoring and medical surveillance.

ANSI American National Standards Institute.

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

Chemical Hygiene Plan A written program developed and implemented by the employer which (1) sets forth procedures, equipment, personal protective equipment, and work practices that are capable of protecting employees from the health hazards presented by hazardous chemicals used in that particular workplace, and (2) meets the requirements of 29 CFR 1910.1450(e).

CHO The Chemical Hygiene Officer, a member of the IUPUI Department of Environmental Health and Safety.

CHP Chemical Hygiene Plan.

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

EHS The IUPUI Department of Environmental Health and Safety

EPA Environmental Protection Agency.

Hazardous chemical A chemical for which there is statistically significant evidence based on at least one study conducted in accordance with established scientific principles that acute or chronic health effects may occur in exposed employees. The term "health hazard" includes chemicals which are carcinogens, toxic or highly toxic agents, reproductive toxins, irritants, corrosives, sensitizers, hepatotoxins, nephrotoxins, neurotoxins, agents which act on the hematopoietic systems, and agents which damage the lungs, skin, eyes, or mucous membranes. (See also definitions of specific and physical hazards.)

Laboratory OSHA defines a laboratory as "a workplace where relatively small quantities of hazardous chemicals are used on a non-productive basis".

Lab Workers The Laboratory Workers referred to in the Lab Standard are employees. OSHA defines an employee as "an individual employed in a laboratory workplace who may be exposed to hazardous chemicals in the course of his or her assignments." An example of a Laboratory Worker would be a University teaching assistant, research assistant or faculty member instructing an academic lab. OSHA would not consider students in an academic laboratory employees. However, as a matter of university policy, the principles outlined in this Chemical Hygiene Plan will apply to students in laboratories. Also included, will be visiting professors and volunteers that might be working in the lab. Thus, Laboratory Supervisors must ensure that these groups that are in their laboratories are adequately instructed in safe laboratory procedures.

OSHA The Occupational Safety and Health Administration.

Oxidizer A chemical, other than a blasting agent or explosive as defined in [OSHA Regulations (Standards-29 CFR) - 1910.109a], that initiates or promotes combustion in other materials, thereby causing fire either of itself or through the release of oxygen or other gases.

NFPA National Fire Protection Association.

PEL Permissible exposure limit. PELs are regulatory limits on the amount or concentration of a substance in the air. They may also contain a skin designation.

Physical hazard A combustible liquid, compressed gas, oxidizer, or organic peroxide; or a material with explosive, flammable, pyrophoric, unstable (reactive), or water-reactive properties.

PPE Personal protective equipment.

PI The Principal Investigator (or the Laboratory or Instructional Supervisor).

Reproductive toxin A chemical which affects the reproductive capabilities, or damages the chromosomes (mutation) or fetus (teratogenesis).

Safety Coordinator A safety coordinator (SC) will be designated for each school, department, or other subdivision by the dean, chairman, or director to serve as liaison to EHS.

Select carcinogen Any substance which meets one of the following criteria: (1) it is regulated by OSHA as a carcinogen; or (2) it is listed under the category "known to be carcinogens" in the Annual Report on Carcinogens published by the National Toxicology Program (NTP) (latest edition); or (3) it is listed under Group 1 ("carcinogenic to humans") by the International Agency for Research on Cancer Monographs (IARC) (latest editions); or (4) it is listed in either Group 2A or 2B by IARC or under the category "reasonably anticipated to be carcinogens" by NTP, and causes statistically significant tumor incidence in experimental animals in accordance with any of the following criteria: (a) after inhalation exposure of 6-7 hours per day, 5 days per week, for a significant portion of a lifetime to dosages of less than 10 mg/m3; (b) after repeated skin application of less than 300 (mg/kg of body weight) per week; or (c) after oral dosages of less than 50 mg/kg of body weight per day.

TLV Threshold limit value.

SOP Standard operating procedure

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2.0 CHEMICAL HYGIENE RESPONSIBILITIES

2.1 Background

IUPUI is committed to providing a safe and healthful environment for all persons associated with the institution. The university intends to be a role model in its environmental stewardship, health protection and safety standards and its compliance with all laws and regulations relating to the environment, health and safety. Management, faculty, staff, and students are asked to support these goals in all university activities and the University administration will provide the necessary resources to achieve these goals.

A vast array of educational activities and research utilizing hazardous materials is conducted at the university that requires cooperation of all parties involved to ensure that such activities are conducted safely with regard to workers, students, the community, and the environment. The following outlines specific responsibilities associated with laboratory safety and this Chemical Hygiene Plan.

2.2 IUPUI Department of Environmental Health and Safety

The Department of Environmental Health and Safety (EHS) is responsible for providing overall administrative guidance and supervision for the Chemical Hygiene Plan (CHP). Specific responsibilities of EHS include:

- Provide training for managers, supervisors, and safety coordinators concerning requirements of the program and their responsibilities.
- Provide guidance for the preparation of procedures, chemical inventories, and training programs required by the CHP.
- Validate employee training.
- Maintain a master file of documentation and records associated with the CHP, including training, personal exposure, medical surveillance, chemical inventories, and material safety data sheets (MSDSs).
- Handle MSDS requests.

2.3 Chemical Hygiene Officer

The Chemical Hygiene Officer (CHO) is an employee who is qualified by training or experience, to provide technical guidance for the continuing implementation of the CHP. The Chemical Hygiene Officer for IUPUI is the Laboratory Safety Manager. Specific responsibilities of the CHO include:

- Work with administrators and other employees to develop and implement appropriate chemical hygiene policies and practices.
- Monitor procurement and use of chemicals in the lab, including determining that facilities and training levels are adequate for the chemicals in use.
- Perform annual chemical hygiene and housekeeping inspections including inspections of emergency equipment.
- Maintain current knowledge concerning the legal requirements of regulated substances in the laboratory.
- Review and improve the Chemical Hygiene Plan on an annual basis.
- Maintain overall responsibility for laboratory safety.
- Monitor employee knowledge and adherence to the chemical hygiene rules.
- Aid in determining the proper level of personal protective equipment.
- Ensure that appropriate training has been provided to employees.

2.3.1 Chemical Laboratory Inspections

Compliance with federal, state, and local regulations is the responsibility of the laboratory Principal Investigator (PI). Many agencies require regulatory compliance depending on the activity being performed. Chemicals are primarily regulated by OSHA, the EPA, and the Department of Homeland Security at the state or federal level. During an actual regulatory inspection, the University and the department can be cited and fined for violations. Because of the potential safety and liability that exists when laboratory safety deficiencies are identified, a corrective action process has been prepared to enforce compliance. The PI is responsible for ensuring that all safety deficiencies documented in a laboratory inspection are corrected. Disciplinary action will be implemented if correction of the deficiencies has not begun within two weeks of

receipt of the Laboratory Safety Survey. It is anticipated that the vast majority of laboratories will correct required deficiencies before corrective action will need to be taken.

Imminent danger or egregious violations are cause to terminate laboratory operations immediately. The Office of Environmental Health and Safety (EHS) provides free compliance assistance at any time.

2.3.1.1 Laboratory Safety Inspection Process

A Laboratory Safety Survey shall be completed annually by Laboratory Safety Technicians. The PI or representative shall be sent an inspection request by a Laboratory Safety Technician. This request will contain the date and time of the inspection and a pre-inspection form. The pre-inspection form must be completed and returned to the Laboratory Safety Technician.

Following the initial laboratory inspection, results will be e-mailed to the PI or contact person. The PI will be given 10-15 business days (or 2-3 weeks) from the receipt of the survey report to begin to correct violations and a written verification of complete or partial corrections is required by the end of that time period.

Failure to take sufficient corrective action by the follow-up inspection or the severity of remaining violations will determine if the process proceeds to disciplinary action.

Disciplinary action will consist of 3 levels:

Level 1

No response was received or no progress has been made since receiving the Laboratory Safety Survey. A full re-inspection of the laboratory will be conducted. EHS laboratory safety staff will send copies of the reinspection report to the PI and the Department Laboratory Safety Coordinator. The EHS laboratory safety staff will discuss the Level 1 re-inspection report with the PI or lab manager to agree upon corrective actions. The PI will be given an additional ten (10) business days to correct all violations. Written verification of corrected deficiencies must be submitted to EHS within that time period. A follow-up inspection will be conducted to verify that all corrections have been made unless written verification is deemed sufficient.

Level 2:

If written verification has not been submitted within the additional ten (10) day time period, a re-inspection and follow up inspection will be conducted if necessary. The IUPUI Laboratory Safety Manager will send a letter and copies of inspections and any PI responses to the PI, the Laboratory Safety Coordinator, the Laboratory Safety Committee, and the Department Chair or Director. The letter will give the PI an additional five (5) business days to correct remaining violations and submit written verification. Mandatory retraining of lab personnel will be considered if the violations reveal a lack of understanding or deliberate avoidance of lab safety guidelines.

Level 3:

If written verification of completed corrective actions has not been submitted to EHS by the end of the process through Level 2 (a total of 25-30 business days), The Laboratory Safety Committee will send a letter of non-compliance to the PI, the Department Laboratory Safety Coordinator, the Department Chair or Director, and the head of the college, school, or unit administration. A re-inspection and follow up inspection will be conducted if necessary.

Failure of the PI to submit verification of corrections will impact their ability to obtain approvals for permits and grant certifications requiring validation of compliance with applicable state and federal regulations, including Federal Certification of Environmental Compliance.

Extensions to provide corrective action may be requested in writing at any stage of this process from EHS laboratory safety staff.

2.4 Managers and Supervisors

Lab managers and supervisors are responsible for maintaining safe operations in their labs on a daily basis. Specific responsibilities include:

- Attend training provided by EHS concerning the requirements of this program and their responsibilities, or send their representative who shall be the safety coordinator (SC) for the work area.

- Ensure that the Chemical Hygiene Plan is customized for their lab and incorporated into routine training sessions for their respective work areas. This program must be written,

applicable to the individual chemical process, and at least as stringent as the requirements of this document.

- Include standard operating procedures for specific laboratory procedures in CHP Section 3.2.

- Ensure employee training at the time of initial assignment to the area, whenever a new hazard is introduced to the area or when the employee is reassigned to an area using new or different materials and/or processes.

- Provide appropriate personal protective equipment and require its proper use and maintenance.

- Ensure an inventory is completed for all chemicals used in their work areas following the instructions provided by EHS.

- Review and understand MSDSs on materials used by employees under their direct supervision and inform employees as new MSDSs become available.

- Ensure MSDSs are available in the work area and are readily accessible to employees.

- Ensure that employee requests for MSDSs and other materials are promptly handled, requesting any necessary information or help from EHS.

- Ensure that **all** containers of hazardous materials are labeled with the chemical name or trade name.

- Ensure that safe and healthful work conditions are maintained.

2.5 Safety Coordinator

A safety coordinator (SC) will be designated for each school, department, or other subdivision by the dean, chairman, or director to serve as liaison to EHS and the CHO. Responsibilities of the SC include:

- Provide information about chemical hazards to contract employees or IUPUI maintenance employees working in the area.

- Serve as a conduit for information between laboratories in their area and EHS and the CHO.

- Assist EHS or CHO with the collection of chemical inventory information.

- Review Laboratory Safety Surveys and ensure that all required deficiencies have been corrected.

- Insure that all employees complete appropriate safety training

- Provide safety information to all departmental lab users when EHS furnishes it to LSCs.

- Update EHS when there are changes in professional staff (chairman, director, professor, post-doc, etc.) or changes in mailing addresses of existing staff.

- Perform periodic inspections or walkthrough laboratories and ensure laboratory personnel correct any safety issues seen.

2.6 Laboratory Workers

All laboratory personnel's responsibilities include the following:

- Report any suspected job-related injuries or illnesses to the Laboratory Supervisor and seek treatment immediately

- Refrain from the operation of any equipment or instrumentation without proper instruction and authorization

- Remain aware of the hazards of the chemicals in the lab and how to handle hazardous chemicals safely

- Request information and training when unsure how to handle a hazardous chemical or procedure

- Follow all safety and health standards and rules.

- Report all hazardous conditions to the supervisor.

- Wear or use prescribed protective equipment.

- Refrain from operating equipment that has safety defects.

- Complete all required safety trainings

- Keep informed about chemicals used in the lab

- Know the location of and be familiar with all relevant Safety Data Sheets

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3.0 OPERATING PROCEDURES

3.1 Purpose

The Lab Standard requires operating procedures relevant to safety and health considerations to be followed when laboratory work involves the use of hazardous chemicals. This Plan represents a minimum set of guidelines for IUPUI laboratories handling hazardous chemicals.

3.2 General Standard Operating Procedures

The General Standard Operating Procedures are fundamental safety precautions which should be familiar to all lab users. These practices should be followed at all times.

3.2.1 Chemical Procurement

- The decision to procure a chemical shall be a commitment to handle and use the chemical properly from initial receipt to ultimate disposal.
- Prior to ordering a chemical, the user must determine that appropriate containment and personal protective equipment are available for its use. The Chemical Hygiene Officer will assist in this determination.
- Personnel who receive chemical shipments shall be knowledgeable of the proper procedures for receipt and Department of Transportation (DOT) compliance. Chemical containers shall not be accepted without accompanying labels, material safety data sheets and packaging in accordance with all appropriate regulations. All chemical shipments should be dated when received and opened.

3.2.2 Chemical Storage

- Received chemicals shall be immediately moved to the designated storage area. Large glass containers shall be placed in carrying containers or shipping containers during transportation.

- The storage area shall be well-illuminated, with all chemical storage maintained below eye level. Large bottles shall be stored no more than two feet from ground level.

- Chemicals shall be segregated by hazard classification and compatibility in a well-identified area, with local exhaust ventilation.

- Highly toxic chemicals shall be stored in unbreakable secondary containers.

- When chemicals are taken from the storage area, they shall be placed in an outside container or bucket.

- Storage of chemicals at the lab bench or other work areas shall be limited to those amounts necessary for work currently in progress.

- The amounts of chemicals at the lab bench shall be as small as practical.

- Stored chemicals shall be examined annually by the Chemical Hygiene Officer or his designee for replacement, deterioration, and container integrity. The inspection should determine whether any corrosion, deterioration, or damage has occurred to the storage facility as a result of leaking chemicals.

- Periodic inventories of chemicals outside the storage area shall be conducted by the Chemical Hygiene Officer or his designee. Unneeded items shall be properly discarded or returned to the storage area.

3.2.3 Chemical Handling

Each laboratory employee with the training, education and resources provided by supervision, shall develop and implement work habits consistent with this CHP to minimize personal and co-worker exposure to the chemicals in the laboratory. Based on the realization that all chemicals inherently present hazards in certain conditions, exposure to all chemicals shall be minimized.

General precautions which shall be followed for the handling and use of all chemicals include:

- Skin contact with all chemicals shall be avoided.

- All employees shall wash all areas of exposed skin prior to leaving the laboratory.

- Mouth suction for pipeting or starting a siphon is prohibited.

- Eating, drinking, smoking, gum chewing, or application of cosmetics in areas where laboratory chemicals are present is prohibited.

- Storage, handling and consumption of food or beverages shall not occur in chemical storage areas or refrigerators. Glassware and utensils used for laboratory operations shall not be used for food or drink consumption or preparation.

- Any chemical mixture shall be assumed to be at least as toxic as its most toxic component.

- Substances of unknown toxicity shall be assumed to be toxic.

- Laboratory employees shall be familiar with the symptoms of exposure for the chemicals with which they work and the precautions necessary to prevent exposure.

- In all cases of chemical exposure, neither the Permissible Exposure Limits (PELs) of OSHA (see Appendix B) or the Threshold Limit Values (TLVs) of the American Conference of Governmental Industrial Hygienists (ACGIH) shall be exceeded.

3.2.4 Laboratory Equipment and Glassware

Each employee shall keep the work area clean and uncluttered. At the completion of each work day or operation, the work area shall be thoroughly cleaned and all equipment properly cleaned and stored. In addition, the following procedures shall apply to the use of laboratory equipment:

- All laboratory equipment shall be used only for its intended purpose.

- All glassware will be handled and stored with care to minimize breakage; all broken glassware will be immediately disposed of in an appropriately labeled broken glass container constructed with corrugated cardboard or other puncture-resistant material.

- All evacuated glass apparatus shall be shielded to contain chemicals and glass fragments should implosion occur.

- All laboratory equipment shall be inspected by the user on a periodic basis for safety defects, and replaced or repaired as necessary.

- Glassware and sharps should be handled and stored carefully to avoid damage. Chipped, broken, or star-cracked glassware should be discarded or repaired. Damaged glassware should never be used unless it has been repaired.

- Because of the potential for catastrophic breakage resulting in sharp projectiles, only thick walled, pressure-resistant glassware should be utilized under positive pressure or a vacuum.

- Appropriate hand protection should be used when inserting glass tubing into a rubber stopper or when placing rubber tubing on glass hose connections. Use of plastic or metal connectors should be considered.

- Appropriate hand protection should be used when picking up broken glass or other sharp objects. Small pieces should be swept up using a brush and dustpan.

3.2.4.1 Glassware Assembly

Borosilicate glassware is recommended for all laboratory glassware except for special experiments that use ultra violet (UV) or other light sources. The only soft glass provided in the laboratory should be reagent bottles, measuring equipment, stirring rods, and tubing.

Any glass equipment to be evacuated, such as suction flasks, should be specially designed with heavy walls. Dewar flasks and large vacuum vessels should be taped or otherwise screened or contained in a metal jacket to prevent flying glass in the case of an implosion. Household Thermos bottles have thin walls and are not acceptable substitutes for laboratory Dewar flasks.

3.2.4.1.1 Preparation of Glass Tubing and Stoppers

Cutting Glass Tubing

- Hold the tubing against a firm support and make one quick firm stroke with a sharp triangular file or glass cutter long enough to extend approximately one-third round the circumference.

- Cover the tubing with cloth and hold the tubing in both hands and away from the body.

- Place the thumbs on the tubing opposite the nick 2 to 3 cm (1 in.) apart and extended toward each other.

- Push out on the tubing with the thumbs as you pull the sections apart, but do not deliberately bend the glass with the hands. If the tubing does not readily pull apart, the nick probably is too shallow or rounded.

- Make a fresh sharp file scratch in the same place and repeat the operation. Avoid accidental contact of the tubing with a nearby person by standing with your back toward a wall or lab bench.

- All glass tubing and rods, including stirring rods, should be fire polished before use. Unpolished cut glass has a razor-like edge, which not only can lacerate the skin, but will also cut into a stopper or rubber hose, making it difficult to insert the glass properly. After polishing or bending glass, allow ample time for it to cool before grasping it.

Drilling a Stopper

- Use only a sharp borer one size smaller than that which will just slip over the glass tube.

- Lubricate rubber stoppers with water or glycerol.

- Bore the hole by slicing through the stopper, twisting with moderate forward pressure, grasping the stopper only with the fingers, and keeping the hand away from the back of the stopper.

- Keep the index finger of the drilling hand against the barrel of the borer and close to the stopper to stop the borer when it breaks through.

- It is preferable to drill only part way through and then finish by drilling from the opposite side. Discard a stopper if a hole is irregular or does not fit the inserted tube snugly, if it is cracked, or if it leaks.

- Corks should have been previously softened by rolling and kneading. Rubber or cork stoppers should fit into a joint so that one-third to one-half of the stopper is inserted.

- When available, glassware with ground joints is preferable. Glass stoppers and joints should be clean, dry and lightly lubricated.

Inserting glass tubes into stoppers or flexible tubing

- Make sure the diameter of the tube or rod is compatible with the diameter of the hose or stopper.

- If not already fire polished, fire polish the end of the glass to be inserted; let it cool.

- Lubricate the glass. Water may be sufficient but glycerol is a better lubricant.

- Wear heavy gloves or wrap layers of cloth around the glass and protect the other hand by holding the hose or stopper with a layered cloth pad.

- Hold the glass rod or tube near the end to be inserted, not more than 5 cm (2 in) from the end.

- Insert the glass with a slight twisting motion, avoiding too much pressure and torque.

- If necessary, use a cork borer as a sleeve for insertion of glass tubes.

- Substitute a piece of metal tubing for glass tubing if possible.

- Remove stuck tubes by slitting the hose or stopper with a sharp knife.

Glass Apparatus Assembly

The following recommendations will help make apparatus assembly easier, safer, and avoid equipment failure during use:

- Keep your workspace free of clutter.

- Set up clean, dry apparatus, firmly clamped and well back from the edge of the lab bench or hood with due regard to the proximity of reagent bottles to burners and to other workers and their equipment.

- Choose sizes that can properly accommodate the operation to be performed, allowing 20% free space at the minimum.

- Use only equipment that is free from flaws such as cracks, chips, frayed wire, and obvious defects. Glassware can be examined in polarized light for stains. Even the smallest chip or crack renders glassware unusable; chipped or cracked ware should be repaired or discarded.

- A properly placed pan under a reaction vessel or container will act as a secondary containment to confine spilled liquids in the event of glass breakage.

- Addition and separatory funnels should be properly supported and oriented so that the stopcock will not be loosened by gravity. A retainer ring should be used on the stopcock plug. Glass stopcocks should be freshly lubricated. Teflon stopcocks should not need lubrication.

- Condensers should be properly supported with securely positioned clamps. The attached water hoses must be secured to the glass fittings with wire or appropriate hose clamps.

- Stirrer motors and vessels should be secured to maintain proper alignment. Magnetic stirring is preferable.

- Apparatus attached to a ring stand should be positioned so that the center of gravity of the system is over the base and not to one side.

- There should be adequate provision for removing burners or baths quickly.

- Stands bearing heavy loads should be firmly attached to the bench top.

- Equipment racks should be securely anchored at the top and bottom.

Operational Precautions

The following precautions should be considered prior to assembly and during operation of the apparatus.

- When working with flammable gases or liquids, do not allow burners or other ignition sources in the vicinity.

- Use appropriate traps, condensers, or scrubbers to minimize release of vapors to the environment.

- If a hot plate is used, ensure that the temperatures of all exposed surfaces are less than the autoignition temperature of the chemicals likely to be released and that the temperature control device and the stirring or ventilating motors do not spark

- Only non-sparking motors or pneumatic motors should be used in chemical laboratories.

- Whenever possible, use controlled electrical heaters or steam in place of gas burners.

- Inspect power cords for chemical or physical damage by unplugging the equipment then bending the cord to look for cracks in the insulation. Be sure to check carefully and close to the point where the power cord enters the housing.

- Apparatus, equipment, or chemical bottles should not be placed on the floor.

- Never heat a closed container. Provide a vent as part of the apparatus for chemicals that are to be heated. Prior to heating a liquid, place boiling stones in unstirred vessels (except test tubes).

- If a burner is to be used, distribute the heat with a ceramic-centered wire gauze.

- Use a thermometer with its bulb in the boiling liquid if there is the possibility of a dangerous exothermic decomposition as in some distillations. This will provide a warning and may allow time to remove the heat and apply external cooling. The setup should allow for fast removal of heat.

- Whenever hazardous gases or fumes are likely to be evolved, an appropriate gas trap should be used and the operation confined to a fume hood.

- Fume hoods are recommended for all operations in which toxic or flammable vapors are evolved as in many distillations.

- Most vapors have a density greater than that of air and will settle on a bench top or floor where they may diffuse to a distant burner or ignition source. These vapors will roll out over astonishingly long distances and, if flammable, an ignition can cause a flash back to the source of the vapors. Once diluted with significant amounts of air, vapors move in air essentially as air itself.

- Use a hood when working with a system under reduced pressure (which may implode).

- Close the sash to provide a shield. If a hood is not available, use a standing shield. Shields that can be knocked over must be stabilized with weights or fasteners. Standing shields are preferably secured near the top. Proper eye and face protection must be worn even when using the shields or hood.

3.2.4.2 Centrifuge Safety

Centrifuges, which operate at high speed, have great potential for injuring users if not operated properly. Unbalanced centrifuge rotors can result in injury or death. Sample container breakage can release aerosols that are harmful if inhaled.

The majority of all centrifuge accidents result from user error. To avoid injury, workers should follow the manufacturer's operating instructions for each make and model of centrifuge that they use.

Follow these steps for the safe operation of centrifuges:

- Follow all manufacturers' recommendations.
- Ensure that centrifuge bowls and tubes are dry.
- Ensure that the spindle is clean.
- Use matched sets of tubes, buckets and other equipment.
- Always use safety centrifuge cups to contain potential spills and prevent aerosols.
- Inspect tubes or containers for cracks or flaws before using them.
- Maintain a rotor log.
- Derate and retire rotors for age/use.
- Avoid overfilling tubes or other containers (e.g., in fixed angle rotors, centrifugal force may drive the solution up the side of the tube or container wall).
- Balance load carefully
- Ensure that the rotor is properly seated on the drive shaft.
- Make sure that tubes or containers are properly balanced in the rotor.
- Only check O-rings on the rotor if you are properly trained.

- Apply vacuum grease in accord with the manufacturer's guidelines.
- Do not exceed the rotor's maximum run speed.
- Close the centrifuge lid during operation.
- Make sure that the centrifuge is operating normally before leaving the area.
- Make sure that the rotor has come to a complete stop before opening the lid.
- When centrifuging infectious materials, wait 10 minutes after the rotor comes to a complete stop before opening the lid.
- If a spill occurs, use appropriate decontamination and cleanup procedures for the spilled materials.

3.2.5 Personal Protective Equipment

Personal protective equipment (PPE) is selected based on the potential hazard presented by the work. Each laboratory procedure should be scrutinized individually for potential hazards based on the chemicals to be used and the procedure to be performed. The hazard assessment is then used to determine the appropriate personal protective equipment.

Each laboratory group is responsible for assessing the potential hazards presented by their work. The Personal Protective Equipment Hazard Assessment Form found in Appendix D can be used for this purpose. The potential hazards presented by typical laboratory procedures and the corresponding personal protective equipment are found on the form. The list does not include all laboratory procedures. Additional tasks and personal protective equipment should be added as necessary on the form.

A list of chemicals that require skin protection can be found in Appendix C. These chemicals have been identified by the Occupational Safety and Health Administration (OSHA) and/or the American Conference of Governmental Industrial Hygienists (ACGIH) as chemicals that present a significant risk of skin absorption and subsequent toxicity. This is not a comprehensive list as many chemicals not on the list also require the use of gloves and other personal protective equipment. Never underestimate the risk of exposure.

Always practice good chemical hygiene and use personal protective equipment.

3.2.5.1 Hand Protection

No glove is resistant to all chemicals. Consult the glove manufacturer's selection guides for chemical compatibility or relevant safety data sheet prior to use. For further information contact the IUPUI Chemical Hygiene Officer at (317) 278-6150.

When selecting and using gloves always:

- Consider chemical resistance, thickness, length, and dexterity requirements.
- Inspect all gloves before use for signs of swelling, cracking, discoloration, pinholes, etc.
- Consider double gloving (wearing one glove over another) as a precaution.
- Change gloves frequently or as often as needed if they become contaminated.
- Do not wear gloves into the hallways.
- Do not touch doorknobs, phones, etc., when wearing gloves. (Remove them before touching anything to prevent leaving chemical residue on the item.)
- Remove gloves by pinching the material in the palm and turning them inside out as the glove is removed over the finger tips (thus keeping contamination on the inside of the removed glove.)
- Rinse thicker reusable gloves after every use.
- Exercise caution when using latex gloves due to the potential for latex allergies. Latex allergy symptoms include skin rash and inflammation, respiratory irritation, asthma and shock. Once a worker demonstrates allergic symptoms to latex, special precautions are needed to prevent exposures during work. Certain medications may reduce the allergy symptoms, but complete latex avoidance is the most effective approach and the worker should switch to a non-latex glove.
- Thermal-resistant gloves shall be worn for operations involving the handling of heated materials and cryogenic fluids. Thermal-resistant gloves shall be non-asbestos and shall be replaced when damaged or deteriorated.

- Chemical resistance is based on several characteristics of the glove material. When selecting the appropriate glove, the following properties should be considered:

  Degradation
  Degradation is the change in one or more of the physical properties of a glove caused by contact with a chemical. Degradation typically appears as hardening, stiffening, swelling, shrinking or cracking of the glove. Degradation ratings indicate how well a glove will hold up when exposed to a chemical. When looking at a chemical compatibility chart, degradation is usually reported as E (excellent), G (good), F (fair), P (poor), NR (not recommended) or NT (not tested).

  Breakthrough Time
  Breakthrough time is the elapsed time between the initial contact of the test chemical on the surface of the glove and the analytical detection of the chemical on the inside of the glove.

  Permeation Rate
  Permeation rate is the rate at which the test chemical passes through the glove material once breakthrough has occurred and equilibrium is reached. Permeation involves absorption of the chemical on the surface of the glove, diffusion through the glove, and desorption of the chemical on the inside of the glove. Resistance to permeation rate is usually reported as E (excellent), G (good), F (fair), P (poor), NR (not recommended), or NT (not tested). If chemical breakthrough does not occur, then permeation rate is not measured and is reported ND (none detected). Manufacturers stress that permeation and degradation tests are done under laboratory test conditions, which can vary significantly from actual conditions in the work environment. Users may decide to conduct their own tests, particularly when working with highly toxic materials or chemicals for which no data can be found. This should always be done carefully in a fume hood with PPE and without touching the chemicals or contaminated materials with the hands (e.g., use forceps). For mixtures, it is recommended that the glove material be selected based on the shortest breakthrough time.

3.2.5.2 Eye and Face Protections

Protective eyewear is *required* whenever there is a reasonable probability that the eyes could be exposed to chemicals. The type of eyewear required depends on the hazard classification of the area and procedure to be performed. IUPUI has 3 classes of laboratories. A class 1 lab does not require eye protection as no

eye hazards are present. A class 2 lab requires eye appropriate eye protection if an eye hazard is present and a class 3 lab requires appropriate eye protection at all times while in the laboratory. Please see the IUPUI Policy on Eye Protection in Laboratories in appendix A for further guidance on laboratory classifications. The eye classification can be found on the laboratory hazard signage posted at the entrance to the laboratory. Below are some basic recommendations on the selection of the appropriate eye and face protection.

Safety Glasses

Safety glasses have shatter resistant lenses made of materials like polycarbonate plastic with side shields attached to the temples that meet the specifications of the American National Standards Institute Standard Z87.1-1989. Safety glasses are designed to stop physical objects or harmful radiation such a laser light from entering the eyes and provide little or no protection from vapors or liquids.

Goggles

Chemical safety goggles are the preferred eye protection to be worn when chemicals are handled in the laboratory and must be worn if a splash hazard exists. These should be worn *over* prescription glasses.

Goggles come in two types: vented and non-vented. Non-vented goggles are used to protect your eyes from vapors, mists, fumes, or other eye hazards that require complete eye coverage with no leaks or perforations. Vented goggles are used where there are moderate quantities of liquids being used but no vapors or mists are involved. There are several types of vented goggles. The type of vented goggles made for laboratory use has a series of buttons embedded into the plastic. These buttons house a baffle plate that allows air to pass but presents a physical barrier to liquids. Do not use the common vented goggle with simple holes drilled in the sides. This type of vented goggle will not stop liquids from coming in through the holes and is not suitable for laboratory work.

Face Shields

Face shields are designed to augment goggles and are not meant to be a sole form of eye protection. Face shields are used to protect your entire face to catch any liquids that might splash onto the face and must be worn when pouring corrosive chemicals that could burn the face or cryogenic

liquids that could frostbite the face as well as other chemical handling operations as procedures dictate

3.2.5.3 Protective Clothing

Protective clothing in the form of lab coats, aprons, and closed-toed shoes are required whenever the possibility of chemical contamination to the body exists.

- Protective clothing that resists physical and chemical hazards should be worn over street clothes.
- Lab coats and aprons should be left in the laboratory and not taken home.
- Laboratory coats should be laundered on a periodic basis (at least monthly). Laboratory coats shall be removed immediately upon discovery of significant contamination.
- Disposable outer garments such as Tyvek suits, aprons, and lab coats may be useful when cleaning and decontamination of reusable clothing is difficult.
- Shorts, sandals loose clothing (including ties), or torn clothing are inappropriate for work with hazardous chemicals and must not be worn in laboratories.
- Lab coats are appropriate for minor chemical splashes and spills. They should be worn buttoned with the sleeves covering the arms. Do not roll up the sleeves.
- Rubber or plastic aprons are appropriate for handling corrosives or irritating liquids.
- Shoes should be worn at all times where chemicals are stored or used.
- Perforated shoes, sandals or cloth sneakers are prohibited in laboratories where hazardous chemicals are stored or used.
- Although generally not required in most laboratories, steel-toed safety shoes may be necessary when there is a risk of heavy objects falling or rolling onto the feet, such as in bottle-washing operations, animal care facilities, or if large quantities of liquids are stored and moved in drums.

3.2.5.4 Respiratory Protection

Respiratory protection is typically provided by using adequate engineering controls such as chemical fume hoods, canopy hoods, snorkel hoods, glove boxes, and appropriately equipped biological safety cabinets. It should be noted that not all biological safety cabinets provide protection from toxic chemical vapors and fumes. These devices should be carefully selected and used only for their intended purpose.

A respirator may only be used when engineering controls, such as general ventilation or a fume hood, are not feasible or do not reduce the exposure of a chemical to acceptable levels. Respirator usage shall comply with the OSHA Respiratory Protection Standard, 29 CFR 1910.134, and the IUPUI Respiratory Protection Program. Contact IUPUI EHS at (317) 274-2005 for more information or to obtain a respirator and arrange the required respirator fit test and medical examination.

3.2.6 Personal Work Practices

- Laboratory supervision must ensure that each employee knows and follows the rules and procedures established in this plan.
- All employees shall be alert for unsafe practices and conditions in the laboratory and shall immediately report such practices and/or conditions to the laboratory supervisor. The supervisor must correct unsafe practices and/or conditions promptly.
- Long hair and loose-fitting clothing shall be confined close to the body to avoid being caught in moving machine/equipment parts.
- Use only those chemicals appropriate for the ventilation system.
- Avoid unnecessary exposure to all chemicals by any route.
- Do not smell or taste any chemicals.
- Working alone in the laboratory is not appropriate; if this is necessary, arrange for periodic checks by personnel in adjacent laboratories.

- Seek information and advice from knowledgeable persons, standards and codes about the hazards present in the laboratory. Plan operations, equipment and protective measures accordingly.

- Use engineering controls in accordance with Section 5.0.

- Inspect personal protective equipment prior to use, and wear appropriate protective equipment as procedures dictate and when necessary to avoid exposure.

3.2.7 Labeling

- All incoming containers in the laboratory shall be labeled. The label shall be informative and durable, and at a minimum, will identify contents, source, date received and opened, and indication of hazard.

- All secondary containers shall be labeled by the individual using the container with the complete chemical name of the contents.

- All food items used in the lab shall be labeled "Not for human consumption".

- All microwaves used in the laboratory shall be labeled "Not for food use".

- All refrigerators and freezers shall be labeled "No food, drinks or flammables" unless it is a fire safe refrigerator. If it is a fire safe refrigerator it shall be labeled with "No food or drinks".

- Existing labels on incoming containers shall not be removed or defaced unless appropriately relabeled immediately with the required information.

- The labeling program shall be periodically inspected by the Chemical Hygiene Officer or his designee to ensure that labels are attached and in good condition

3.2.8 Reactive Chemicals

Reactives are substances that have the potential to vigorously polymerize, decompose, condense, or become self-reactive due to shock, pressure, temperature, light, or contact with another material. All reactive hazards involve the release of energy in a quantity or at a rate too great to be dissipated by the immediate environment of the reaction system

so that destructive effects occur. Reactive chemicals include: 1) **explosives**, 2) **organic peroxides**, 3) **water-reactives** and 4) **pyrophorics**.

3.2.8.1 Explosives

A chemical that causes sudden, almost instantaneous release of pressure, gas, and heat when subjected to sudden adverse conditions. Heat, light, mechanical shock, detonation, and certain catalysts can initiate explosive reactions. Compounds containing the functional groups azide, acetylide, diazo, nitroso, haloamine, peroxide, or ozonide are sensitive to shock and heat and can explode violently.

- Appropriate personal protective equipment (e.g., face shield, safety goggles, leather outer gloves, chemical resistant gloves, fire-resistant or all cotton lab coat) should be worn when working with explosives.
- Before working with explosives, understand their chemical properties, know the products of side reactions, know the incompatibility of certain chemicals, and monitor environmental catalysts such as temperature changes.
- Containers should be dated upon receipt and when opened. Expired explosives should be discarded promptly.
- Explosives should be kept to the minimum necessary for the procedure.
- If there is a chance of explosion, use protective barriers (e.g., fume hood sash and safety shield) or other methods for isolating the material or process.
- Explosives should be stored in a cool, dry, and protected area. Segregate from other material that could create a serious risk to life or property should an accident occur.

3.2.8.2 Organic Peroxides

These chemicals contain an -O-O- structure bonded to organic groups. These compounds can be considered as structural derivatives of hydrogen peroxide, H-O-O-H, in which one or both of the hydrogen atoms have been replaced by an organic group. Generally, organic peroxides are low-powered explosives that are sensitive to shock, sparks, and heat due to the weak -O-O- bond which can be cleaved easily. Some organic compounds such as ethers, tetrahydrofuran, and p-

dioxane can react with oxygen from the air forming unstable peroxides. Peroxide formation can occur under normal storage conditions, when compounds become concentrated by evaporation, or when mixed with other compounds. These accumulated peroxides can violently explode when exposed to shock, friction, or heat.

- Appropriate personal protective equipment (e.g., safety goggles, gloves, fire-resistant or all cotton lab coat) should be worn when working with organic peroxides or peroxide-forming compounds.

- Containers should be labeled with the receiving and opening dates. Unopened material should be discarded upon expiration date or 1 year after receiving and opened material should be discarded within 12 months.

- Containers should be airtight, and stored in a cool, dry place away from direct sunlight and segregated from incompatible chemicals.

- Peroxide-formers, liquid peroxides, or solutions should not be refrigerated below the temperature at which the peroxide freezes or precipitates. Peroxides in these forms are extra sensitive to shock (never store diethyl ether in a refrigerator or freezer).

- Unused peroxides should never be returned to the stock container.

- Metal spatulas should not be used with peroxide-formers. Only ceramic or plastic spatulas should be used. Contamination by metal can cause explosive decomposition.

- Friction, grinding, and all forms of impact, especially with solid organic peroxides should be avoided. Never use glass containers with screw cap lids or glass stoppers. Instead, use plastic bottles and sealers.

- Testing for the presence of peroxides should be performed periodically.

- Containers with obvious crystal formation around the lid or viscous liquid at the bottom of the container should NOT be opened or moved. Call EHS at (317) 274-2005 for further guidance.

3.2.8.3 Water Reactives

A chemical that reacts with water or moisture in the air (humidity) releasing heat or flammable, toxic gas. Examples include alkali metals, alkaline earth metals, carbides, hydrides, inorganic chlorides, nitrides, peroxides, and phosphides.

- Appropriate personal protective equipment (e.g., safety goggles, gloves, fire-resistant or all cotton lab coat) should be worn when working with water-reactives.
- Water-reactives should be stored under mineral oil in a cool, dry place and isolated from other chemicals.
- Water-reactives should not be stored near water, alcohols, and other compounds containing acidic OH.
- In case of fire, keep water away. Appropriate fire extinguishers should be available in areas where water-reactives are used (use a Type "D" fire extinguisher to extinguish active metal fires).

3.2.8.4 Pyrophorics

A chemical that ignites spontaneously in air below 130^{o} F (54^{o} C). Often the flame is invisible. Examples of pyrophoric materials include silane, silicon tetrachloride, white and yellow phosphorus, sodium, tetraethyl lead, potassium, nickel carbonyl, and cesium.

- Appropriate personal protective equipment (e.g., safety goggles, gloves, fire-resistant or all cotton lab coat) should be worn when working with pyrophorics.
- Pyrophorics should be used and stored in inert environments.
- Appropriate fire extinguishers should be available in areas where pyrophorics are used.
- All users of pyrophorics must take the IUPUI Working Safely with Pyrophorics training available online.

3.2.9 Compressed Gases

In general, a compressed gas is any material contained under pressure that is dissolved or liquefied by compression or refrigeration. Compressed gas cylinders should be handled as high-energy sources and therefore as potential explosives and projectiles. Prudent safety practices should be followed when handling compressed gases since they expose workers to both chemical and physical hazards.

- Safety glasses with side shields (or safety goggles) and other appropriate personal protective equipment should be worn when working with compressed gases.
- Cylinders should be marked with a label that clearly identifies the contents.
- All cylinders should be checked for damage prior to use. Do not repair damaged cylinders or valves. Damaged or defective cylinders, valves, etc., should be taken out of use immediately and returned to the manufacturer/distributor for repair.
- Always store cylinders in an upright position, on a level floor and secured using a restraint such as chains, sturdy straps or plastic coated wire or attach the cylinder to a non-tip base.
- All gas cylinder restraints should be rigidly secured to a substantial structure at 2/3 height.
- Only soldered link chains or belts with buckles are acceptable. Cylinder stands are also acceptable but not preferred.
- Handcarts shall be used when moving gas cylinders. Cylinders must be chained to the carts.
- All cylinders must be fitted with safety valve covers before they are moved.
- A pressure-regulating device shall be used at all times to control the flow of gas from the cylinder.
- The main cylinder valve shall be the only means by which gas flow is to be shut off.
- Cylinder valves should never be lubricated, modified, forced, or tampered.
- After connecting a cylinder, check for leaks at connections. Periodically check for leaks while the cylinder is in use.
- Regulators and valves should be tightened firmly with the proper size wrench. Do not use adjustable wrenches or pliers because they may damage the nuts.

- Cylinders should not be placed near heat or where they can become part of an electrical circuit.

- Cylinders should not be exposed to temperatures above 50 C (122 F). Some small cylinders, such as lecture bottles, are not fitted with rupture devices and may explode if exposed to high temperatures.

- Rapid release of a compressed gas should be avoided because it will cause an unsecured gas hose to whip dangerously and also may build up enough static charge to ignite a flammable gas.

- Appropriate regulators should be used on each gas cylinder. Threads and the configuration of valve outlets are different for each family of gases to avoid improper use. Adaptors and homemade modifications are prohibited.

- Cylinders should never be bled completely empty. Leave a slight pressure to keep contaminants out.

- When not in use cylinders should be stored with their main valve closed and the valve safety cap in place.

- Cylinders awaiting use should be stored according to their hazard classes.

- Cylinders should not be located where objects may strike or fall on them.

- Cylinders should not be stored in damp areas or near salt, corrosive chemicals, chemical vapors, heat, or direct sunlight. Cylinders stored outside should be protected from the weather.

- Lecture bottles should be stored according to their hazard classes.

- Lecture bottles which contain toxic gases should be stored in a ventilated cabinet.

- Lecture bottles should be stored in a secure place to eliminate them from rolling or falling.

- Lecture bottles should not be stored near corrosives, heat, direct sunlight, or in damp areas.

- To avoid costly disposal fees, lecture bottles should only be purchased from suppliers that will accept returned bottles (full or empty). Contact the supplier before purchasing lecture bottles to ensure that they have a return policy.

- Lecture bottles should be dated upon initial use. It is advised that bottles be sent back to the supplier after one year to avoid accumulation of old bottles.

- All employees using hydrogen gas must take the IUPUI online Hydrogen Safety Training.

3.2.9.1 Gas Cartridge Bunsen Burners

Bunsen burners and compressed flammable gas cartridges present hazards to the IUPUI community. Bunsen burners produce an open flame and burn at a high temperature, and as a result, there is potential for an accident to occur. Flammable gas cartridges contain flammable gas under pressure and have the potential for explosion and/or fire. Laboratory personnel who use gas cartridge Bunsen burners must read and follow the safety procedures and requirements found in the IUPUI Bunsen Burner policy which is located in Appendix D of this plan. Only gas cartridge Bunsen burners meeting the requirements found in the IUPUI Bunsen Burner Policy are allowed on this campus.

3.2.10 Cryogenic Liquids

Cryogenic liquids are liquefied gases having boiling points of less than -73.3^{o} C (-100^{o} F). The primary hazards of cryogenic liquids include both physical hazards such as fire, explosion, and pressure buildup and health hazards such as severe frostbite and asphyxiation. Potential fire or explosion hazards exist because cryogenic liquids are capable, under the right conditions, of condensing oxygen from the atmosphere. This oxygen-rich environment in combination with flammable/combustible materials and an ignition source are particularly hazardous. Pressure is also a hazard because of the large volume expansion ratio from liquid to gas that a cryogen exhibits as it warms and the liquid evaporates. This expansion ratio also makes cryogenic liquids more prone to splash and therefore skin and eye contact is more likely to occur. Contact with living tissue can cause frostbite or thermal burns, and prolonged contact can cause blood clots that have very serious consequences. All laboratory personnel should follow prudent safety practices when handling and storing cryogenic liquids.

- Appropriate personal protective equipment should be worn when handling cryogenic liquids. This includes special cryogen gloves, safety goggles, full face shield, impervious apron or coat, long pants, and high topped shoes. Gloves should be impervious and sufficiently large to be readily removed should a cryogen be spilled. Watches, rings, and other jewelry should NOT be worn.

- Unprotected body parts should not come in contact with vessels or pipes that contain cryogenic liquids because extremely cold material may bond firmly to the skin and tear flesh if separation is attempted.

- Objects that are in contact with cryogenic liquid should be handled with tongs or proper gloves.

- All precautions should be taken to keep liquid oxygen from organic materials; spills on oxidizable surfaces can be hazardous.

- All equipment should be kept clean, especially when working with liquid or gaseous oxygen.

- Work areas should be well ventilated.

- Transfers or pouring of cryogenic liquid should be done very slowly to minimize boiling and splashing.

- Cryogenic liquids and dry ice used as refrigerant baths should be open to the atmosphere. They should never be in a closed system where they may develop uncontrolled or dangerously high pressure.

- Liquid hydrogen should not be transferred in an air atmosphere because oxygen from the air can condense in the liquid hydrogen presenting a possible explosion risk.

- Cryogenic liquids should be handled and stored in containers that are designed for the pressure and temperature to which they may be subjected. The most common container for cryogenic liquids is a double-walled, evacuated container known as a Dewar flask.

- Containers and systems containing cryogenic liquids should have pressure-relief mechanisms.

- Cylinders and other pressure vessels such as Dewar flasks used for the storage of cryogenic liquids should not be filled more than 80% of capacity to protect against possible thermal expansion of the contents and bursting of the vessel by hydrostatic pressure. If the possibility exists that the temperature of the cylinder may increase to above 30o C (86o F), a lower percentage (e.g., 60 percent capacity) should be the limit.

- Dewar flasks should be shielded with tape or wire mesh to minimize flying glass and fragments should an implosion occur.

- Dewar flasks should be labeled with the full cryogenic liquid name and hazard warning information.

3.2.11 Electrical Safety

Serious injury or death by electrocution is possible when appropriate attention is not given to the engineering and maintenance of electrical equipment and personal work practices around such equipment. In addition, equipment malfunctions can lead to electrical fires. By taking reasonable precautions, electrical hazards in the laboratory can be dramatically minimized.

- Laboratory personnel should know the location of electrical shut-off switches and/or circuit breakers in or near the laboratory so that power can be quickly terminated in the event of a fire or accident.

- Electrical panels and switches should never be obstructed and should be clearly labeled to indicate what equipment or power source they control.

- All electrical equipment should be periodically inspected to ensure that cords and plugs are in good condition. Frayed wires and wires with eroded or cracked insulation should be repaired immediately, especially on electrical equipment located in wet areas such as cold rooms or near cooling baths. Insulation on wires can easily be eroded by corrosive chemicals and organic solvents. Inspect power cords by unplugging the equipment then bending the cord to look for cracks in the insulation. Be sure to check carefully and close to the point where the power cord enters the housing.

- All electrical outlets should have a grounding connection requiring a three-pronged plug.

- Outlet expanders and grounded to ungrounded converters are prohibited.

- All electrical equipment should have three-pronged, grounded connectors. The only exceptions to this rule are instruments entirely encased in plastic (such as electric pipetters and some types of microscopes) and Glas-Col heating mantels. If equipment does not have a three-pronged plug, replace the plug and cord to ground the equipment.

- Face plates must not be removed from electrical outlets.

- Electrical wires should not be used as supports.

- Extension cords should be avoided. If used, they should have three-pronged, grounded connectors and positioned or secured as not to create a tripping hazard.

- All shocks should be reported to the principal investigator or supervisor. All faulty electrical equipment should be immediately removed from service until repaired.

- Electrical outlets, wiring, and equipment within a laboratory or building should only be repaired by IU Physical Plant or other professional electricians.

- Proper grounding and bonding of flammable liquid containers should be practiced to avoid the build-up of excess static electricity. Sparks generated from static electricity are good ignition sources.

3.2.12 Hazardous Chemical Spill Response- E.S.C.A.P.E.

- **E**xit the area — Immediately after a hazardous chemical is spilled you must exit the area. If the spill occurred in a laboratory and access to the fume hood is not blocked by the spill and/or hazardous vapors are not present in the area then raise the sash on the fume hood and increase the airflow.

- **S**hut the doors and secure the area — Shut the doors to the area where the spill is located and secure the area if possible. Most laboratories are under negative pressure which will pull air from the hallway into the lab, keeping potentially hazardous vapors from spreading into other areas.

- **C**all 911 from a campus phone or 317-274-7911 from a non-campus phone from a safe location and give the following information:

    - Building name

    - Room number or location

    - Type of incident

    - Name of chemical spilled or description of odor if unsure of the chemical

    - Estimate of the volume of chemical spilled

- **A**ssess the situation — Determine if the spill is Immediately Dangerous to Life or Health (IDLH). IDLH incidents are those that pose a significant and immediate threat to building occupants due to extreme toxicity, imminent explosion, or other

life threatening scenario. These types of incidents are rare. If the spill does not pose a threat to the building occupants then remain outside the entrance to the laboratory until the spill response team arrives. If you determine that the situation is Immediately Dangerous to Life or Health, then proceed to the next step.

- **P**ull the fire alarm — After determining that the spill poses an immediate danger to the building occupants pull the fire alarm. Activating the fire alarm will evacuate the building occupants and will also notify the Indianapolis Fire Department.

- **E**xit the building — Once the fire alarm has been activated exit the building. Remain at a safe distance from the main entrance of the building. Give your information to the emergency response teams that will be arriving.

- Chemical Contamination:

    - Remove any contaminated clothing immediately and flush all areas of bodily contact with copious amounts of water. This should take place while someone else makes the appropriate phone calls and in a safe location.

    - Ensure that medical assistance is obtained for those injured or exposed (safety shower, medical attention, etc.). Continue to rinse body contact areas with copious amounts of water for at least 15 minutes unless directed otherwise by appropriate emergency medical personnel (Physician, Nurse, Paramedic or Emergency Medical Technician).

    - Visit IUPUI Health Services or the IU Hospital Emergency Room for medical care and evaluation. If possible, take applicable Material Safety Data Sheets (MSDS) with you.

- Radiation Release

    - The *Radiation Safety Procedures Manual* gives detailed instructions on what to do in the event of a release involving radioactive material. Basic instructions include the following:

    - Contact the Radiation Safety Office at 317-274-4797.

    - Notify everyone in the area of the release and limit access.

    - Prevent the spread of contamination (e.g. cover with absorbent paper/chucks).

    - All individuals involved should remain in the area until monitored for contamination.

3.2.12 Nanotechnology Safety

Nanomaterials are defined as ultrafine particles with a dimension of one to 100 nanometers in diameter. One nanometer is one-billionth of a meter. Low-solubility ultrafine particles are more toxic than larger particles on a mass-for-mass basis. In addition to the hazardous properties of the chemical constituents, their smaller dimensions, larger surface area, and ability to penetrate cell membranes more easily than larger particles add to the hazardous properties of these materials.
Because of their small particle size, they can be deposited deep into the lungs and, once in the bloodstream, may be able to cross the blood-brain barrier. Exposure to these materials during synthesizing processes and use may occur through inhalation, ingestion, and contact with the skin or eyes.
Other hazards to consider are catalytic effects and fire or explosion. Particles in the nanometer size range are currently being evaluated for toxicity and critical exposure levels based on mass, surface area, and the number of particles per unit volume. Until these factors are determined workers should implement stringent controls on exposure when working with them.

All employees who work with nanoparticles must take the IUPUI Working Safely with Nanoparticles training as well as review the IUPUI Guidelines for Safe Use and Handling of Nanomaterials found in Appendix I.

Below are some basic guidelines for working with nanomaterials.

- Use good general laboratory safety practices as found in this Laboratory Chemical Safety Plan.
- Wear gloves, lab coats, safety glasses, face shields, closed-toed shoes as needed.
- Be sure to consider the hazards of precursor materials in evaluating process hazards.
- OSHA's "Particularly Hazardous Substances" (such as cadmium) must be handled in a containment device such as a fume hood or a glove box.
- Avoid skin contact with nanoparticles or nanoparticle-containing solutions by using appropriate personal protective equipment. Do not handle nanoparticles with your bare skin.
- If it is necessary to handle nanoparticle powders outside of a fume hood or HEPA-filtered powered-exhaust laminar flow hood, wear appropriate respiratory protection. The appropriate respirator should be selected based on professional consultation with EHS.

- Use fume exhaust hoods to expel fumes from tube furnaces or chemical reaction vessels.

- Dispose of and transport waste nanoparticles according to the hazardous chemical waste guidelines.

- Vacuum cleaners used to clean up nanoparticles should be factory tested, HEPA-filtered units.

- Equipment previously used to manufacture or handle nanoparticles should be evaluated for potential contamination prior to disposal or reuse for another purpose. Lab equipment and exhaust systems should also be evaluated prior to removal, remodeling, or repair.

- Given the differing synthetic methods and experimental goals, no blanket recommendation can be made regarding aerosol emissions controls. This should be evaluated on a case by case basis.

- Consideration should be given to the high reactivity of some nanomaterials with regard to potential fire and explosion hazards.

- EHS Laboratory Safety and Environmental Management should be contacted prior to beginning work with nanomaterials.

3.2.13 Laboratory Close Outs

Please see the IUPUI Laboratory Decommissioning Policy for guidance on laboratory close outs found in appendix A. Proper transfer or disposal of hazardous materials is required whenever a Principal Investigator or Responsible Individual leaves the University or transfers to a different laboratory. A "Responsible Individual" can include, but is not limited to: faculty, staff, post-doctoral, and graduate students.

Plan the transfer or disposal of hazardous materials carefully. Hazardous materials such as chemicals, microorganisms, tissues, and radioactive materials can injure faculty, students, staff, contractors and visitors if handled inappropriately.

The primary responsibility for the proper management of all hazardous materials used in laboratories, including compliance with the IUPUI laboratory Decommissioning Policy, lies with the principal investigator or researcher. The department or unit is responsible for ensuring that the principal investigator manages and disposes of these materials properly. The IUPUI Office of Environmental Health and Safety (EHS) will

provide guidance and disposal services for the principal investigator and department or unit.

3.3 Procedure-Specific Safety Procedures

Laboratory must have procedure specific Standard Operating Procedures in place before work begins. Written laboratory standard operating procedures normally have a description of specific safety measures for that particular procedure. Lab workers should read and review those practices before beginning a procedure.

3.4 Special Procedures for Particularly Hazardous Substances

Special precautions shall be taken when performing laboratory work with any of the following inimical chemical categories: carcinogens, reproductive toxins, substances that have a high degree of acute toxicity, or chemicals whose toxic properties are unknown.

3.4.1 Inimical Chemical Categories

- Carcinogens - Both known and suspect cancer-causing chemicals reported in the latest edition of the National Toxicology Program's "Carcinogens Summary" (see Section VII of the Reference Manual).
- Reproductive Toxins - Chemicals including mutagens and teratogens identified as such by the Material Safety Data Sheet.
- Acute Toxicity Chemicals - Any substance for which the LD_{50} data described in the applicable MSDS (or other literature source) cause the substance to be classified as a level 3 or 4 health hazard according to the HMIS system (see Section XIII of the Reference Manual).
- Chemicals Whose Toxic Properties are Unknown - Chemicals for which there is no known statistically significant study conducted in accordance with established scientific principles that establishes its toxicity.

3.4.1.1 Precautions for Inimical Chemical Use

- Allow only those persons specifically trained to work with inimical chemicals to work with those chemicals.

- Designated Area - A hood, glove box, portion of a laboratory, or an entire laboratory must be designated for inimical chemical use.

- Designated areas shall be posted and their boundaries clearly marked. Posting shall include the identification of inimical chemicals used in the area.

- Access to the laboratory may be restricted during inimical chemical use by the laboratory supervisor or CHO.

- Suitable gloves and long sleeves shall be worn during use of inimical chemicals (see Section XVII of the Reference Manual).

- Use the smallest amount of chemical that is consistent with the requirements of the work to be done.

- Use high-efficiency particulate air (HEPA) filters or high-efficiency scrubber systems to protect vacuum lines and pumps.

- Decontaminate a designated area when work is completed.

- Store all inimical chemicals in locked and enclosed spaces at all times when not in use.

- Retain all inimical chemical wastes for disposal by EHS (see Section XIX of the Reference Manual).

3.5 Prior Approval for Laboratory Activities

Certain activities that present specific, foreseeable hazards for laboratories and their users may require prior approval from their department and/or the CHO. These activities include, sole occupancy of building, hazardous operations, use of new procedures or chemicals, and unattended operations.

3.5.1 Sole Occupancy in the Building

Under normal circumstances, work should not be done in the laboratory when the only person in the building is the laboratory person performing the work. If this is necessary, periodic checks on that person should be made by personnel in adjacent buildings.

3.5.2 Hazardous Operations

All hazardous operations are to be performed during a time when at least two people are present at the laboratory. At no time shall a laboratory person, while working alone in the laboratory, perform work which is considered hazardous. The determination of hazardous operations shall be made by the laboratory supervisor and/or CHO.

3.5.3 New Procedures or Chemicals

Prior to the use of new procedures or chemicals, a review of potential hazards created must be undertaken within the department. The review should also be completed when there is a substantial change in the amount of chemicals used or a change in the equipment used in the procedure.

3.5.4 Unattended Operations

When laboratory operations are performed which will be unattended by laboratory personnel (continuous operations, overnight reactions, etc.), the following procedures will be employed:

- The laboratory supervisor will review work procedures to ensure the safe completion of the operation.
- An appropriate sign will be posted at all entrances to the laboratory.
- The overhead lights in the laboratory will be left on.
- Precautions shall be made for the interruption of utility services during the unattended operation (loss of water pressure, electricity, etc.).
- Containment will be provided in the event of unexpected hazardous material releases.

- Tubing for running water must be in good condition and secured at connections by clamps or wire.

4.0 CRITERIA FOR IMPLEMENTATION OF CONTROL MEASURES

4.1 Air Sampling

- Air sampling for evaluating employee exposure to chemical substances shall be conducted periodically or as indicated by specific codes or regulations.

- Upon addition of new chemicals or changes in control procedures, additional air sampling will be considered to determine the exposures.

- Air sampling will be conducted if there is reason to believe that exposure levels for regulated substances exceed the action level, or in the absence of an action level, the PEL.

- The results of air sampling studies performed in the laboratory are maintained by EHS.

4.2 Housekeeping

Each laboratory worker is directly responsible for the cleanliness of his or her work space, and jointly responsible for common areas of the laboratory. Laboratory management shall insist on the maintenance of housekeeping standards. The following procedures apply to housekeeping standards of the laboratory:

- The lab benches shall be kept clear of equipment and chemicals except those necessary for the work currently being performed.

- The work area shall be cleaned at the end of each operation or each day.

- All apparatus shall be thoroughly cleaned and returned to storage upon completion of usage.

- All floors, aisles, exits, fire extinguishing equipment, eye washes, electrical disconnects and other emergency equipment shall remain unobstructed.

- All labels shall face front.

- Chemical containers shall be clean, properly labeled and returned to storage upon completion of usage.

- All chemical wastes will be disposed of promptly in accordance with the waste disposal plan.

4.3 Safety and Emergency Equipment

- Telephone numbers of emergency personnel, supervisors and other workers as deemed appropriate shall be posted and provided to EHS.

- All laboratory personnel will be aware of the location and proper use of fire safety and emergency equipment.

- Prior to the procurement of new chemicals, the Chemical Hygiene Officer or the laboratory supervisor shall verify that safety and emergency equipment are appropriate for such chemicals.

- Eye washes shall be inspected and flushed for 5 minutes weekly by laboratory employees. Showers shall be inspected by EHS at least annually. Records shall be maintained for eye wash and shower inspections.

- Location signs for safety and emergency equipment shall be posted.

5.0 ENGINEERING CONTROLS

5.1 Intent

The engineering controls installed in the laboratory are intended to minimize employee exposure to chemical and physical hazards in the workplace. These controls must be maintained in proper working order for this goal to be realized.

5.2 Modification

No modification of engineering controls will occur unless testing indicates that worker protection will continue to be adequate.

5.3 Improper Function

Improper function of engineering controls must be reported to the Chemical Hygiene Officer and to Campus Facility Services Trouble Line (278-1900) immediately. The system shall be taken out of service until proper repairs have been executed.

5.4 Usage

5.4.1 Laboratory Fume Hoods

The laboratory fume hoods shall be utilized for all chemical procedures which might result in release of hazardous chemical vapors or dust. As a general rule, the fume hood shall be used for all chemical procedures involving substances which are volatile and have a permissible exposure limit (PEL) less than 100 ppm or are flammable materials. The following work practices shall apply to the use of fume hoods:

- Confirm adequate hood ventilation performance prior to opening chemical containers inside the hood. An inward flow of air can be confirmed by holding a thin strip of tissue at the face of the hood and observing the movement of the paper.

- Keep the sash of the hood at or below the indicated maximum operating height except when adjustments within the hood are being made. At these times, maintain the sash height as low as possible.

- Storage of chemicals and equipment inside the hood shall be kept to a minimum.
- Minimize interference with the inward flow of air into the hood.
- Locate apparatus toward the rear of the hood and keep all work at least 6 inches inside the hood to prevent vapors from escaping.
- Do not place items against the back wall which will obstruct the baffles and impede the airflow.
- Leave the hood operating when it is not in active use if hazardous chemicals are contained inside the hood or if it is uncertain whether adequate general laboratory ventilation will be maintained when the hood is non-operational.
- The hood shall not be used as a means of disposal for volatile chemicals.
- The ventilation system shall be inspected annually by EHS. The average hood face velocity shall be at least 80 feet per minute for standard fume hoods and at least 60 feet per minute for high efficiency or high performance hoods. A record of each inspection shall be maintained by the Chemical Hygiene Officer.

5.4.2 Glove Boxes and Isolation Rooms

The exhaust air from a glove box or isolation room will pass through HEPA filters or other treatment before release into the regular exhaust system.

5.4.3 Flammable Storage Cabinets

Cabinets designed for the safe storage of flammable chemicals can only do so if used and maintained properly. Cabinets are generally made of double-walled construction and are made of 18 gage steel. The doors are two inches above the base and the cabinet is liquid proof to that point. Two vents are provided on opposite sides of the cabinet and are equipped with flame-arrestor screens. Always read the manufacturer's information and follow prudent safety practices such as:

- Store only compatible materials inside the cabinet.
- Store chemicals of similar vapor density together when using mechanical ventilation (e.g., heavier than air vapors are vented through the bottom vent and lighter than air vapors through the top vent).

- Do not store paper or cardboard inside cabinets with the chemicals.
- Do not overload the cabinet.
- Do not store corrosives inside the cabinet.

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6.0 EMPLOYEE INFORMATION AND TRAINING

6.1 Training Organization

All IUPUI employees working in a laboratory environment must attend the mandatory Laboratory Safety Training class. This class is offered monthly, and can also be offered at other dates by contacting the Environmental Health and Safety Department. This training fulfills the OSHA Laboratory Standard requirements.

6.2 Training Timing and Frequency

Information and training shall be provided to laboratory employees on the following basis:

- New employees shall complete all required training programs.
- Current employees who have changed positions or are assigned to begin working in a laboratory must complete all required training programs.
- All employees shall be informed of updated information via Lab Notes and/or online refresher training.

6.3 Training Components

This section contains safety training programs that are offered by the IUPUI Office of Environmental Health and Safety. All employees who work in laboratories that house or utilize hazardous materials are required to take Laboratory Safety Training. All IUPUI Employees are also required to take New Employee Safety Orientation. The hazard specific safety trainings below are required if the employee is using or has a potential to be exposed to the specific hazard described in the training. Please visit our website at www.ehs.iupui.edu for a complete list of available safety trainings and instructions for taking our online training.

6.3.1 Laboratory Safety Training

All employees working in a laboratory are required to take this training upon employment. This training is available in a classroom setting and also online. Please visit our website at www.ehs.iupui.edu to view the training schedule and locations. This training shall include methods of detecting the presence of hazardous chemicals, physical and health hazards of chemicals in the lab, and measures employees can take

to protect themselves from these hazards. The training shall present the details of the Chemical Hygiene Plan, and shall include:

- The contents of the OSHA laboratory standard, and its appendices.
- The location and availability of the Chemical Hygiene Plan.
- The physical and health hazards of chemicals in the work area.
- Signs and symptoms associated with exposure to the chemicals present in the laboratory.
- Location, availability, and how to use reference material on chemical hygiene including Material Safety Data Sheets.
- The criteria for selection and use of personal protective equipment and the limits of its protection.
- Emergency procedures and the location of emergency equipment.

6.3.2 New Employee Safety Orientation

All IUPUI employees are required to take this training upon employment. This training is only available in a classroom setting. Please visit our website at www.ehs.iupui.edu to view the training schedule and locations.

6.3.3 Bloodborne Pathogens Training

The Bloodborne Pathogens Training is mandatory for all IUPUI employees who could be "reasonably anticipated" to face contact with blood and other potentially infectious materials as the result of performing their job duties, and are covered under the OSHA Bloodborne Pathogen Standard (29 CFR 1910.1030). An annual refresher retraining is also required and can be taken online.

6.3.4 Laser Safety Training

All employees who are working with class 3B or class 4 non-sealed beam lasers are required to take this training. This training is available online.

6.3.5 Anesthetic Gas Safety Training

All employees who work with or supervise work involving anesthetic gases at the IUPUI campus shall complete the training. This training is available online.

6.3.6 Formaldehyde Hazard Communications Training

All IU employees with an occupational exposure to formaldehyde (i.e. formaldehyde gas, formaldehyde solutions and any other compound or material that releases formaldehyde gas) are required to take this training. This training is available online.

6.3.7 Hydrogen Gas Safety Training

All IUPUI employees who use hydrogen gas in the laboratory must take this training. This training is available online.

6.3.8 Working Safely with Nanomaterials

All IUPUI employees working with nanomaterials must take this training. This training is available online.

6.3.9 Pyrophoric Safety Training

All IUPUI employees working with pyrophoric chemicals in their laboratory are required to take this training. This training is available online.

6.4 Training Documentation

The safety coordinator is responsible for ensuring that all employees in their department, required per section 6.1, have completed all required safety trainings. A copy of training records shall be maintained by the Chemical Hygiene Officer.

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7.0 LABORATORY SIGNAGE

7.1 Introduction

The signage system is designed to fulfill regulatory signage requirements as well as alert lab users and visitors to specific hazards located in individual laboratories. The lab signs do not list every hazard associated with a lab and do not replace basic laboratory safety training or practice.

Accurate door postings facilitate emergency response actions by providing immediate information to firefighters, paramedics, and others. Incorrect postings may place others in danger and/or delay implementation of measures to control and minimize certain emergency situations (e.g., fire, explosion, etc.), thereby increasing the damage to the room and/or other portions of the building.

7.2 Hazard Assessment and Laboratory Signage Program (HALS)

HALS is a web based program designed to assist laboratory supervisors in identifying the hazards present in their laboratories and communicating this information to anyone who enters their labs. The laboratory PI or his representative can log onto the IUPUI Environmental Health and Safety Website at www.ehs.iupui.edu and click on the link to the HALS program at http://www.ehs.iupui.edu/hals/home.asp.

The Laboratory PI or his representative will then complete an electronic profile of the laboratory, and the information is incorporated into a door sign. The sign lists the name of the principal investigator and the name of an alternate contact that are responsible for the room, along with corresponding contact numbers.

The PI must select the most important hazards in their lab area from a list of twelve hazard types (see section 7.2.1 for the Hazard Definition Tables), and then rate the risk level as “low”, “moderate”, or “high” for each hazard. For biological hazards present in the laboratory please choose from BSL1, BSL2 or BSL3. If radioactive materials are in use in the laboratory then please indicate “Present” on the pull down menu. Please note that you must have approval from Radiation Safety before a sign can be posted indicating radioactive materials in use. Please also indicate, using the drop down menu, if your laboratory eye classification is a class 1, class 2 or class 3.

The sign indicates any limitations on access, and also provides an area for you to type any additional warnings you would like posted.

All laboratory signs will automatically state “No Food or Drink allowed”.

7.3 Hazard Definition Tables

Biohazard

Definition: Organisms or their products that may cause harm to humans or animals. Example: disease-causing microorganisms. Immuno-compromised individuals (who lack resistance to infection) may be at an increased risk of health effects from biohazards. These people should discuss their condition with their supervisors so that, if appropriate, additional precautions would be followed.

BSL1: Microbiology lab using microorganisms that do not cause disease in healthy adults. Examples: E. Coli bacteria, yeast "Biosafety Level 1".

BSL2: Organisms that can cause moderate to serious illness in healthy adults. Infections seldom occur via inhalation unless the organism is dispersed into the air as an aerosol. Infections readily occur from needle sticks or accidental contact with mucous membranes such as eyes and mouth. Ex: Human blood and body fluids, salmonella bacteria, hepatitis B. "Biosafety Level 2".

BSL3: Organisms that can cause serious illness or death in healthy adults. Exposure by inhalation is a risk from any sort of handling procedures or from spills or contaminated waste. Infections also readily occur from needle sticks or accidental contact with mucous membranes such as eyes and mouth. Example: the bacteria that cause TB. "Biosafety Level 3".

Carcinogen

Definition: Chemicals that cause malignant tumors, or other forms of cancer. Examples: some organic compounds (anthracene, aflatoxin), some solvents (chloroform, benzene), and some metals (hexavalent chromium).

Low: Occasional use of small amounts or dilute solutions. Example: Entomology lab using small quantities of dilute formaldehyde/water solutions to preserve specimens

Moderate: Routine use of material in pure form, such as acrylamide powder or diaminobenzidine (DAB), or use of several liters per week of carcinogenic solvents, such as phenol/chloroform extraction procedures.

High: Routine use of larger quantities of carcinogenic material where the risk of exposure is high because the material can be absorbed through skin or inhaled.

Flammable Liquid

Definition: Liquids that ignite easily and burn rapidly, and have a flash point less than 100F (37.7C).Examples: 95% ethanol, ether, hexane, acetone, and ethyl acetate

Low: Daily use of small quantities. Example: microbiology lab using alcohol for wiping bench tops.

Moderate: Routine use of highly volatile solvents in moderate quantities, away from ignition sources or the storage of up to 25 gallons. Examples: solvent extractions, refluxing or solvent distillation.

High: (1) Routine use of large quantities (2) any work with flammable liquids near an open flame or at elevated temperatures. Storage of over 25 gallons.

Chemical Storage

Definition: Storage of material that is not in use, excluding the hazard classes of flammable gases, flammable liquids, oxidizers, poison inhalation hazards, and water reactives, which are considered separately.

Low: Storage of small quantities of chemicals. Storage where the amount on hand would not cause a fire or serious health hazard if it came into accidental contact with water. No storage of poison inhalation hazards. Example: chemical storage in a teaching lab.

Moderate: Storage of hundreds of chemical containers. Minimal amounts of air or water reactive material, unstable or incompatible chemicals, or compressed or liquefied gases. Example: chemical inventory of a large research group.

High: Chemical stockrooms, large quantities of hazardous materials, including 55 gallon drums. Storage of significant amounts of air or water reactive material, unstable or incompatible chemicals, and/or compressed or liquefied gases.

Compressed Gas

Definition: Containers of compressed, liquefied or solidified gases which pose a risk of asphyxiation, and/or the risk of rapid freezing of tissue.
Examples: Compressed oxygen, liquid nitrogen, and dry ice (solid carbon dioxide). Flammable and highly toxic gases (poison inhalation hazards) are excluded from this category, and are considered separately.

Low: Use where a) the release rate of the gas can be controlled and b) the area is well ventilated and air is not re-circulated. Example: Gas cylinder with regulator used in a well ventilated laboratory where air is exhausted by fume hoods that vent to the roof.

Moderate: (1) Use of compressed gas with a low, well controlled flow rate in an area with poor ventilation or (2) the use of a container or gas supply system that could cause the sudden release of a large amount of gas.
High: Use of any compressed gases, including solidified or liquefied gases, in small un-ventilated space. Example: Use of liquid nitrogen or dry ice in a cold room or environmental chamber. (Note: This applies to rooms/chambers with circulating fans. They do not supply fresh air.)

Poison

Definition: Any substance which, in small quantities, can cause serious illness or death. Examples: arsenic, lead, and pesticides that block nerve transmission. For extensive information about poisons, consult Prudent Practices in the Laboratory published by the National Research Council.

Low: Use and storage of materials for which the lethal dose is more than an ounce (LD50 more than 500mg per kilogram) and that are not readily absorbed through the skin. Examples: methyl ethyl ketone, acetaldehyde, benzoic acid, methanol and hexane.

Moderate: Use and storage of materials for which the lethal dose is between an ounce and a teaspoon (LD50 between 50 to 500 mg per kilogram) OR less toxic compounds which can be absorbed through the skin. Examples: pyridine (skin absorbed), phenol
(skin absorbed), butylamine, coomassie blue, guanidine hydrochloride and zinc chloride.

High: Use and storage of materials for which the lethal dose is less than a teaspoon (LD50 less than 50mg per kilogram).Examples: sodium cyanide, osmium tetroxide, sodium azide and heptafluorobutyric acid.

Corrosive

Definition: Any material that irritates or destructively attacks body tissues such as skin. Corrosive chemicals are typically acids such as hydrochloric acid and sulfuric acid, and bases such as sodium hydroxide and ammonium hydroxide.

Low: Routine use of dilute acid and base solutions, infrequent use of concentrated acids and bases. Example: undergraduate teaching laboratory.

Moderate: Routine use of a variety of strong acids and bases in concentrated form. Example: average chemistry laboratory.

High: Labs with large quantities (more than 10 gallons) of concentrated mineral acids or bases in frequent use, and benchtop use of acid baths with acid concentrations of greater than 6 molar.

Flammable Gas

Definition: Gases that ignite easily and burn rapidly. Common flammable gases are hydrogen, carbon monoxide, and acetylene.

Low: Use of small individual low-pressure containers or piped supply systems. Example: aerosol can of spray paint with a flammable gas as a propellant.

Moderate: Routine use of large high-pressure flammable gas cylinders. Use and storage of up to five large, high pressure cylinders of flammable gases.

High: Daily use of several large high pressure cylinders of flammable gas. Use and storage of 6 or more cylinders in a laboratory. Use or storage of propane cylinders greater than 1.5 pounds.

Explosive

Definition: A chemical compound, usually containing nitrogen that detonates as a result of shock or heat.
Examples: trinitrotoluene (dynamite) and ammonium nitrate. Wetted explosives are Flammable Solids because they ignite easily at low temperatures. For extensive information about the potential for a compound to detonate or react to form an explosive mixture, consult Bretherick's Handbook of Reactive Chemical Hazards.

Low: Use that involves amounts that can not produce a harmful explosion or use of the material in form that is not explosive. Example: histology lab using picric acid solution as a stain.

Moderate: Use that involves amounts that can produce a harmful explosion but use is limited to forms, such as aqueous solutions, that are not explosive. Example: Bouin's fixative.

High: Use of explosive compounds, in quantities that can produce a harmful explosion, in procedures that could produce a form that is explosive. Examples: refluxing diethyl ether (potentially concentrating peroxides), drying of picric acid.

Laser

Definition: Equipment that emits energy as a beam of electromagnetic radiation. Some laser beams are visible light that can be seen when they are present. Some lasers emit infra-red or ultraviolet radiation that is invisible. Medium and high intensity lasers can cause serious eye damage. High intensity lasers can also burn skin and can ignite combustible materials.

Low: Only class I, II, or IIIa lasers are in use. Beams from class I, II and IIIa lasers are always visible. There is no risk of injury unless an individual looks directly into the beam for an extended period of time. Example: HeNe laser pointers used in classrooms

Moderate: Class IIIb laser is in use. Momentary viewing of the direct beam, or a beam reflected from a mirror-like surface, may produce serious eye injury. Beams may not be visible.

High: Class IV laser is in use. Viewing of the direct beam and viewing of any type of reflection is likely to cause serious eye injury. Beams can cause skin burns. Beams can cause materials to burn and/or release hazardous materials to the air.

Oxidizer

Definition: Compounds that readily provide oxygen to support combustion. Oxidizers can initiate a fire as well as cause other materials to burn much more intensely than normal. Examples: peroxides, chlorates, perchlorates, nitrates, and permanganates.

Low: Infrequent use of small quantities under conditions known to be controllable. Example: teaching lab using 10% hydrogen peroxide in an experiment

Moderate: Routine use and storage of moderate quantities of oxidizers. Example: chromic acid bath used to clean glassware.

High: Routine use and storage of large quantities of strong oxidizers Examples: hot perchloric acid digestion, fertilizer storage areas.

Radiation

Definition: Energy emitted from radioactive materials (alpha, beta, gamma radiation) or emitted by radiation producing equipment (X-rays) that can cause chemical changes in living cells that may result in immediate injury or an increased risk of cancer.

Present: Radioactive materials are being used in this laboratory.

You must have Radiation Safety approval to use radioactive materials in your laboratory before you can indicate this hazard on your hazard warning sign.

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8.0 EXPOSURE EVALUATIONS

8.1 Suspected Exposures to Toxic Substances

There may be times when employees or supervisors suspect that an employee has been overexposed to a hazardous chemical that might have caused harm to the victim. If the circumstances suggest a reasonable suspicion of exposure, the victim is encouraged to undergo a medical consultation at Student Employee Health Service. This consultation and any related medical examination shall be provided at no cost with no loss of workday time attributed to the victim.

8.1.1 Criteria of Reasonable Suspicion of Exposure

The Department of Environmental Health and Safety investigates all employee-related incidents where there is or may be overexposure to a toxic substance. The following are examples of some events or circumstances that might reasonably constitute overexposure:

- Victim had direct skin or eye contact with a chemical substance.
- Odor was noticed, especially if person was working with any chemical which has a lower PEL than odor threshold.
- A hazardous chemical leaked, spilled, or was otherwise rapidly released in an uncontrolled manner.
- Manifestation of health hazard symptoms such as headache, rash, nausea, coughing, tearing, irritation or redness or eyes, irritation of nose or throat, dizziness, loss of motor dexterity or judgment, etc.
- Some or all symptoms disappear when person is taken away from chemical area and into fresh air.
- Symptoms reappear soon after person starts working with the same chemicals again.
- Complaints are received from more than one person in the same work area.

8.2 Exposure Evaluations

Once a complaint of possible hazardous chemical exposure has been received, a standard series of steps are taken to elucidate the situation. Unless circumstances suggest other or additional steps, the following actions taken by the CHO will constitute an exposure assessment:

- Interview the person initiating the complaint, and the victim if it is not the same person.
- List essential information about the circumstances of the complaint, including:
    - The chemical under suspicion.
    - All chemicals being used by others in the immediate area.
    - Other chemicals stored in that area.
    - Symptoms exhibited or claimed by victim.
    - Were control measures, such as fume hoods and personal protective equipment, used and used properly?
    - Were any air sampling or monitoring devices in place or available? If so, are the measurements obtained from these devices consistent with other information?
- Perform air sampling in the area for suspect chemicals.
- Determine whether the victim's symptoms compare to the symptoms described in the MSDS or other pertinent scientific literature.
- Review the adequacy of present control measures and safety procedures.
- Notify employee of the results of air sampling within 15 working days of receipt of the results.

9.0 MEDICAL CONSULTATION AND EXAMINATION

9.1 Provisions for Obtaining Medical Care

The details of medical consultations and examinations are determined by the physician. The purpose of a medical consultation is to determine whether a medical examination is warranted. When it is suspected or known that an employee was overexposed to a hazardous chemical or chemicals, the employee should obtain medical consultation from or under the direct supervision of a licensed physician at Student Employee Health Service (SEHS).

When warranted, employees also may also be referred by SEHS to receive a medical examination from or under the direct supervision of a licensed physician who is experienced in treating victims of chemical overexposure. The medical professional should also be knowledgeable about which tests or procedures are appropriate to determine if there has been an overexposure; these diagnostic techniques are called "differential diagnoses". Referral for medical examinations will be made by SEHS.

The following provisions apply to medical consultations and examinations:

- All employees who work with hazardous chemicals must be provided an opportunity to receive medical consultations and examination when:
    - The employee develops signs or symptoms associated with a hazardous chemical to which the employee may have been exposed in the laboratory.
    - Monitoring, routine or otherwise, suggests that there could have been an exposure above the action level (or PEL if there is no action level) for a chemical for which a substance-specific standard has been established.
    - There is a spill, leak, or other uncontrolled release of a hazardous chemical.
- The exposed employee or his supervisor must provide the physician with:
    - The identity of the hazardous chemical or chemicals to which the employee may have been exposed.
    - The exposure conditions.
    - The signs and symptoms of exposure the victim is experiencing, if any.
- Physicians will furnish to the Chemical Hygiene Office in written form:

- Identification of diagnosis related to chemical exposure.
- Recommendations for follow-up, if determined to be pertinent.
- Conclusions concerning any other medical condition noted that could put the employee at increased risk.

- A statement that the employee has been informed both of the results of the consultation or examination and of any medical condition that may require further examination or treatment.
    - These written statements and records should not reveal specific findings that are not related to an occupational exposure.

9.2 Documentation and Notification

EHS will maintain records of all laboratory worker air monitoring, exposure evaluations, and medical consultations and examinations. Employees shall be notified of the results of any medical consultation or examination with regard to any medical condition that exists or might exist as a result of overexposure to a hazardous chemical.

10.0 RECORDS AND RECORDKEEPING

There are several repositories for records relevant to the OSHA Laboratory Standard. OSHA recordkeeping requirements are given in 29 CFR 1910.20. Included in those requirements is the maintenance of air monitoring results, exposure assessments, and medical consultations and examinations for at least 30 years. Records must be made accessible to employees or their representatives. All of the following are recordkeeping requirements of OSHA or IUPUI.

10.1 Departmental Recordkeeping

- Chemical Inventory.
- Material Safety Data Sheets.

10.2 Department of Environmental Health and Safety Recordkeeping

- Area and personal air monitoring results.
- Exposure assessments.
- Laboratory safety inspections.
- Health and safety complaints.
- Safety Training attendance records.

10.3 Employee Health Services Record Keeping

- Medical consultations and examinations.
- Illness/injury information resulting from an exposure or accident on the job that caused lost work time - Information received by SEHS and stored by the Risk Management Department of Indiana University - Bloomington.

11.0 Chemical Hygiene Plan Audit

The Chemical Hygiene Officer will conduct an audit of all phases of the Chemical Hygiene Plan

annually. Changes to the CHP will be printed and distributed to all laboratories using or storing hazardous chemicals.

APPENDICES

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APPENDIX A: LABORATORY SAFETY POLICIES

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IUPUI POLICY ON EATING AND DRINKING IN LABORATORIES

Subject: Eating, Drinking, and Related Activities in Laboratories
Effective Date: February 1, 1997
Approved: Robert Martin, Vice Chancellor - Policy: 101

PURPOSE AND BACKGROUND:

Hazardous materials can be accidentally ingested when eating, drinking, smoking, gum chewing, or related activities are permitted within workplace and teaching laboratories. To eliminate this potential route of exposure, OSHA has developed guidelines which prohibit these activities in areas where laboratory chemicals are present. In addition, OSHA recommends hand washing before these activities are conducted.

SCOPE:

This policy applies to all staff, faculty, students and University guests entering University laboratories.

POLICY:

Eating, drinking, smoking, gum chewing, the application of cosmetics and the storage of food and beverages are not permitted in laboratories containing hazardous materials. These activities may take place in a separate area which is a room with floor to ceiling walls and a door separating the area from the laboratory space in which hazardous materials are used, stored, or transported.

PROCEDURE:

Each school, department, or section is responsible for identifying laboratories where eating, drinking, smoking, and related activities are prohibited. Notifying students and staff of appropriate places for eating, drinking, and related activities is advisable.
When planning renovations or new spaces, consideration should be given to providing appropriate areas for eating and drinking.

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IUPUI EYE PROTECTION IN LABORATORIES POLICY

Subject: Eye Protection in Laboratories
Effective Date: February 1, 1997
Approved: Robert Martin, Vice Chancellor - Policy: 102

SCOPE:

These requirements apply to all staff, faculty, students and University guests entering University laboratories.

POLICY:

Eye protection shall be used according to the following laboratory classification.

LABORATORY CLASSIFICATION SYSTEM

CLASS 1 - EYE PROTECTION NOT REQUIRED
Laboratories that do not use chemicals, biologicals or physically hazardous materials.
Example: computer laboratory
CLASS 2 - EYE PROTECTION REQUIRED WHEN HAZARD EXISTS
Laboratories that use chemicals, biologicals or physically hazardous materials on an occasional basis.
Example: laser laboratory
CLASS 3 - EYE PROTECTION REQUIRED AT ALL TIMES
Laboratories that routinely use chemicals, biologicals, or machinery.
Example: most chemical laboratories

PROCEDURES:

Each department shall determine the hazard class of each laboratory. These requirements shall be posted outside each laboratory door. If a procedure creates a greater hazard than the laboratory classification would indicate, eye and face protection appropriate for the hazard shall be worn. Protective devices will be provided to employees at no charge. Each department will be responsible for enforcement of this approved policy. If the recommended policy does not apply to a particular situation, departments must provide an alternative policy for approval by the Laboratory Safety Committee.

Guidance for the selection of eye and face protection is given in the "American National Standard for Occupational and Educational Eye and Face Protection" (ANSI Z87.1). Environmental Health and Safety will assist in determining the appropriate eye and face protection for specific laboratory hazards and will provide vendor information for securing equipment.

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IUPUI WASTE ANESTHETIC GAS POLICY

Subject: Anesthetic Gas Safety
Effective Date: July 22, 2005
Approved: IUPUI Laboratory Safety Committee

I. Purpose

The Environmental Health and Safety (EHS) Department has developed this policy to protect employees at Indiana University Purdue University at Indianapolis (IUPUI) who have an occupational exposure to anesthetic gases. Inhaled anesthetics include two classes of chemicals: nitrous oxide and halogenated agents. Halogenated anesthetic gases include halothane, isoflurane, sevoflurane, desflurane, enflurane, and methoxyflurane (used infrequently).

The policy set forth is intended to ensure compliance with federal, state, and local requirements. Presently, the Occupational Safety and Health Administration (OSHA) has not adapted a regulation regarding waste anesthetic gases (WAG's). The National Institute for Occupational Safety and Health (NIOSH) and the American Conference of Governmental Industrial Hygienists (ACGIH) both have recommended exposure limits for WAG's

II. Scope

This policy applies to all employees who work with or supervise work involving anesthetic gases at the IUPUI campus. Anesthetic gases are used in laboratories throughout campus during animal surgical procedures and in the dental school during surgical procedures.

III. Responsibilities

EHS is responsible for:

1. The development, implementation, and oversight of the program.
2. Area and personal air monitoring to determine exposure.
3. Ensuring compliance with all federal, state, and local regulations.

The Departments are responsible for:

1. Ensuring that all personnel have been trained prior to anesthetic gas use.
2. Following all safety guidelines for anesthetic gas use.
3. Anesthetic gas equipment maintenance.
4. Reporting any liquid agent spills or releases to EHS.
5. Compliance with IUPUI's Hazard Communication Program.
6. Reporting results of all monitoring to employees.
7. Ensuring completion of an incident report for any health or safety related incidents and forwarding the report to Occupational Health Services and EHS.

Employees are responsible for:
1. Completing the anesthetic gas training course.
2. Following all safety guidelines when working with anesthetic gases.
3. Inspecting all equipment prior to and after each use.
4. Ensuring the scavenge system is used with all anesthetic gas machines.
5. Reporting any problems with equipment to department management.
6. Reporting any liquid agent spills or releases to department management and EHS.
7. Following IUPUI's Hazard Communication Program.
8. Reporting any health or safety concerns to department management and completing an incident report.

IV. Regulatory Limits

Presently, the Occupational Safety and Health Administration (OSHA) has not created or adapted a regulation regarding WAG's. The National Institute for Occupational Safety and Health (NIOSH) and the American Conference of Governmental Industrial Hygienists (ACGIH) both have recommended exposure limits for WAG's. The following table summarizes the recommended exposure limits.

Table 1

Anesthetic Gas	OSHA PEL (ppm) [1]	NIOSH REL (ppm)[2]	ACGIH TLV-TWA (ppm)[3]
Nitrous Oxide (N_20)	None	254	50
Isoflurane	None	Ceiling [5]	None
Halothane	None	Ceiling [5]	50
Desflurane	None	Ceiling [5]	None
Sevoflurane	None	Ceiling [5]	None
Enflurane	None	Ceiling [5]	75

V. Exposure Monitoring

EHS can perform air monitoring to determine the anesthetic gas concentrations in the air. The two types of monitoring performed are personal and area. Personal monitoring is conducted at the employee's breathing zone to determine WAG exposure for the employee. The monitoring is performed using a passive dosimeter which collects gas on a media and is then analyzed by a laboratory. Area monitoring is conducted in the work area to give WAG concentrations in work areas. A portable infrared spectrophotometer, or direct read instrument, is used to collect real time samples. EHS can also perform leak testing on the equipment to determine if gas is escaping from various locations in the machine. A portable infrared spectrophotometer is used to detect leakage.

VI. Training

All employees who work with or supervise work with anesthetic gases shall complete on-line training via EHS's website prior to using any anesthetic gas.

The training shall consist of the following: regulatory limits, health effects of nitrous oxide and halogenated agents, sources of exposure, scavenge systems, anesthetic gas equipment inspections, engineering controls, work practices, administrative controls, liquid agent spills, air monitoring, medical surveillance, and hazard communication. The training shall be conducted upon initial assignment and whenever there is a change in process or procedure.

VII. Information

For additional information regarding IUPUI's anesthetic gas policy, please refer to EHS's Anesthetic Gas Training Program at www.ehs.iupui.edu or contact EHS at 274-2005.

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IUPUI LASER MEDICAL SURVEILLANCE POLICY

Subject: Anesthetic Gas Safety
Effective Date: August 3, 2005
Approved: IUPUI Laboratory Safety Committee

I. PURPOSE

To provide a medical surveillance program for all IUPUI employees and students who operate or maintain a class 3b or class 4 laser. Laser safety programs are detailed in the American National Standard (ANSI) Z136.1.

II. Scope

IUPUI employees who operate and maintain class 3b and class 4 lasers.

III. Policy Statements

A. Medical surveillance will be mandatory for students, research and maintenance personnel who will be operating or maintaining a non sealed-beam class 3b or class 4 laser as described in section 4.0 of the IUPUI Laser Safety Manual. The medical surveillance will include a comprehensive ocular history and visual acuity examination performed in IUPUI Occupational Health Services by the clinical staff. If the visual acuity is worse than 20/20 in on eye or both eyes for far/near vision, or if the ocular history is abnormal, or if there is a history of eye disease, then the employee will need to be seen by the designated physician or nurse practitioner for a comprehensive eye examination.

1. Prior to assignment/baseline.
2. As appropriate for emergency exposure.

B. The Principal Investigator (PI) listed on the Laser Registration Form (form LS-1 in appendix A of the IUPUI Laser safety Manual) is responsible for notifying department heads and IUPUI Department of Environmental Health and Safety (EHS) as to which employees or students should be included in the medical surveillance program

C. Enrolled employees and students will schedule their medical surveillance examination with IUPUI Occupational Health Services. If an exposure occurs, the employee/student should complete the Accident/Exposure report form. The manager, supervisor or PI signs the form. The employee/student reports to IUPUI Occupational Health Services. If the IUPUI Occupational Health Services is closed they should report to the Indiana University Hospital Emergency Department for evaluation and treatment if necessary. The employee/student should always follow up with IUPUI Occupational Health Services the next business day if seen by the Emergency Department.

D. The Principal Investigator listed on the Laser Registration Form (LS-1) is responsible to ensure compliance with the required program.

E. The Laser Safety Officer is responsible for providing education and training that includes: Online laser safety training, ANSI standard regarding laser usage available to all laser users. The Principle Investigator is responsible for laser specific training, Standard Operating Procedures, departmental policies or procedures and notifying IUPUI Occupational Health Services of personnel who are required to be enrolled in the program.

F. IUPUI Environmental Health and Safety (EHS) in collaboration with the Laboratory Safety Coordinators will identify areas where class 3b and class 4 lasers are utilized. The Laboratory Safety Coordinators will supply EHS with an annual list of departments using class 3b and class 4 lasers and any environmental data available.

G. IUPUI Occupational Health Services will perform a baseline and post-exposure evaluations, review the medical surveillance program every 2 years and prepare an annual report to EHS regarding employees compliant with the program. EHS will be responsible for maintaining the medical/exposure records on each enrolled employee/student for at least 30 years.

H. Employees and students identified to be enrolled in the program are responsible to comply and understand that noncompliance may result in disciplinary action.

IV. Exceptions

The Director of EHS will determine any exceptions to this policy

V. Cross Reference

American National Standard (ANSI) Z136.1.

VI. Responsibility

The Director of EHS is responsible for the consistent application of this policy.

VII. Approval Body

IUPUI Environmental Safety Committee

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IUPUI MERCURY ELIMINATION POLICY

Subject: Mercury Reduction/Elimination
Effective Date: June 23, 2006
Approved: IUPUI Laboratory Safety Committee

PURPOSE AND BACKGROUND:

Mercury is recognized by national public health experts as one of the most significant environmental toxicants facing the United States. The public health effects of mercury in the environment are well researched and documented. The United States Environmental Protection Agency and the Indiana Department of Environmental Management have identified the elimination of mercury sources and the proper disposal of mercury as priority public outreach projects for each agency.

Further illustration of this concern occurred in 1998 when the American Hospital Association entered into a memorandum of understanding with the United States Environmental Protection Agency requesting that all member institutions commit to the elimination of all sources of mercury from their facilities within a 5-year period. Due to difficulty in meeting the 5-year deadline, the AHA withdrew its signature from the memorandum of understanding but extended its commitment to the concept of eliminating mercury sources within a reasonable time period.

Mercury is the most commonly spilled chemical product on campus. A significant expenditure of resources is expended each year by University personnel in the remediation of these spills. Improper disposal and/or unrecognized or unreported releases of mercury pose a significant threat to the community and can lead to significant regulatory consequences for the University. In many, if not most cases, effective (from both a performance and cost perspective) alternatives for mercury have been developed and are readily available.

Indiana University – Purdue University Indianapolis, as a generator of hazardous chemical waste, has an obligation under federal and state regulation to reduce the volume and toxicity, including mercury, of these wastes generated to the fullest extent economically practicable.

The Administration of IUPUI recognizes the threat presented by mercury and is committed to reducing this threat to the lowest level practical in as timely fashion as possible.

SCOPE:

By the adoption of this policy, Administration shares this commitment with all staff, faculty, students and guests of the University community.

POLICY:

All nonessential uses of elemental mercury or mercury-based compounds are to be eliminated from campus laboratories by December 31, 2007. Mercury and mercury-based compounds being eliminated from chemical inventories are to be referred to the IUPUI Department of Environmental Health and Safety for proper disposal by means of the *IUPUI Hazardous Materials Manifest for Intracampus Transportation* available at the following link: http://ehs/ehs/manifest_form.asp.

Following December 31, 2007, costs associated with the disposal of mercury wastes will be referred back to the generating department. In addition, all cost associated with the response and remediation of a mercury release will be referred back to the department.

An essential use of mercury is defined as that given circumstance where no acceptable alternative for the current use can be located or where it is found that implementation of the alternative would create a significant, long term financial hardship to the department or research project.

Effective December 31, 2007, no mercury-containing device, elemental mercury or mercury-based chemicals may be acquired without the expressed written consent of the Laboratory Safety Committee.

Laboratories wishing to maintain inventories of mercury products after December 31, 2007 shall contact the IUPUI Environmental Manager at 274-4351 and request an exception to this policy. The Department of Environmental Health and Safety (EHS) will take the request under consideration, will review all appropriate documentation and will render an opinion in writing as to whether the request, in the opinion of the Department, is of merit.

In the event of disagreement, EHS will offer an opinion in writing the next regularly-scheduled Laboratory Safety Committee meeting for consideration by the Committee at large. The laboratory in question will be given an opportunity to present a case in favor of the continued use of the material or item. By means of a vote of a simple majority of those members present at that meeting, a final decision as to whether the proposed use is considered as essential will be rendered.

For those uses found to be essential, the mercury is to be eliminated from the laboratory's inventory once an ongoing need can no longer be demonstrated.

EHS and the Committee will work in a cooperative fashion with any department found to have an unusually large inventory of mercury-based materials or items to allow for the phase-in of alternatives without creating a financial hardship for the department.

In the event a significant need is evident, EHS will explore grant opportunities to help offset the costs of acquiring acceptable alternatives.

NONCOMPLIANCE/PENALTIES:

The Department of Environmental Health and Safety may, at its discretion, refer costs incurred from the disposal of wastes generated by actions contrary to the principles of this policy back to the producing or generating department.

Staff, faculty, students and guests of the University whose willful actions violate existing federal and state regulation may be held criminally and civilly liable for their actions.

In the event the University is cited and fined by federal, state or local regulatory agencies for actions or activities contrary to applicable regulations, the department(s) involved in the citation may be accountable for payment of the issued fine.

In addition, the University may initiate disciplinary actions, up to and including dismissal, against any staff or faculty found to be in violation of this policy.

PROGRAM OVERSIGHT AND EMPLOYEE ASSISTANCE:

The Department of Environmental Health and Safety will serve as a technical resource for the implementation of this program. The Department will also serve to oversee the development and implementation of mercury educational materials as needed.

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IUPUI SERVICING FUME HOOD EXHAUSTS POLICY

Subject: Policy for Servicing Fume Hood Exhaust Systems
Effective Date: May 1, 2008
Approved: IUPUI Laboratory Safety Committee

PURPOSE AND BACKGROUND:

The following policy was developed to protect the Campus Facility Services personnel (CFS) and the IUPUI laboratory occupants from potential exposure to hazardous materials while servicing exhaust systems.

SCOPE:

This policy applies to all work that requires servicing and repairing or dismantling of a chemical fume hood, entering or removing duct work, entering the fan housing, changing filters, shutting off fans or any other maintenance that requires entering the inside of the exhaust system.

Special precautions are usually not required when servicing equipment that is outside of the chemical fume hood cabinet and/or outside of the potentially contaminated air stream. For example, belts and pulleys may be serviced, vibration isolators may be adjusted and lamps may be replaced on many chemical fume hoods without entering the interior of the hood or exhaust duct.

POLICY:

The following procedures will be followed when performing maintenance and/or repairs inside of a fume hood or inside the fume hood exhaust system and when shutting down a fume hood for scheduled or unscheduled maintenance and/or repairs.

PROCEDURES:

Procedure Components

1. Responsibilities
2. Special Operating Procedures
3. Procedures for Servicing a Chemical Fume Hood
4. Procedures for Servicing a Dedicated Exhaust System Fan
5. Procedures for a Shutdown of Multiple Chemical Fume Hoods

6. Maintenance Procedures
7. Unscheduled Shutdown Procedures

1. Responsibilities :

Campus Facility Services

- When service requires that a chemical fume hood or other local exhaust system be shut down, CFS personnel must communicate to the laboratory personnel and/or the Principle Investigator (PI) the need for service and obtain permission to shut down the chemical fume hood and/or the local exhaust system. CFS personnel must also enter a shut down notice to communicate the time and duration of the shut down. If responsible laboratory personnel and/or PI are not available, contact the building manager or department administration to obtain permission to shut down the chemical fume hood or other local exhaust system.
- CFS personnel must not shut down the chemical fume hood or local exhaust systems without permission from an authorized person.
- CFS personnel must complete and post a Shut Down Notice on the sash of the chemical fume hood a minimum of 3 days before the scheduled shut down. Work should not begin if laboratory personnel or PI have not completed the checklist on the Shut Down Notice.
- CFS personnel should contact Radiation Safety if radioactive materials have been used in the hood a minimum of 48 hours before shutdown.
- CFS personnel should contact Environmental Health and Safety (EHS) if any unusual hazards have been used in the hood a minimum of 48 hours before shutdown.
- If work requires entry into the fume hood then CFS should not begin work until all hazardous chemical in the chemical fume hood have been removed and equipment in the hood secured or removed. CFS personnel shall not alter, move or remove laboratory chemicals or equipment.
- CFS personnel must perform work in a manner consistent with established CFS safety procedures and wear the appropriate personal protective equipment (see Section 6 Maintenance Procedures).

Laboratory Supervisor and/or PI

- When work must be done inside of the exhaust system, the laboratory personnel and/or PI must confirm that the sash is shut, hazardous

materials are closed and secure and the fume hood will not be used for the duration of the service work.

- The laboratory personnel or PI must confirm if any radioactive materials or unusual hazards have been used in the hood by completing and signing the Laboratory Personnel checklist section on the maintenance notice a minimum of 48 hours before shutdown.
- As appropriate, the laboratory personnel and/or PI must provide a work area in the laboratory that is cleared of laboratory chemicals and equipment. CFS personnel shall not alter, move or remove laboratory chemicals or equipment.

Environmental Health and Safety

- EHS personnel will inspect the fume hood and/or ductwork before CFS begins work if any unusual hazards have been used or if CFS personnel have reason to believe that unusual hazards may exist.

Radiation Safety

- If radioactive materials have been used in the fume hood, Radiation safety personnel will perform surveys of the work area to verify lack of radioactive contamination.

2. Special Operating Procedures

- **Radioisotope Hoods.** If work is scheduled for a chemical fume hood inside a laboratory posted with a "Caution Radioactive Materials" sign and/or when laboratory personnel have indicated that radioactive materials have been used in the hood on the Shut Down Notice, CFS personnel will contact Radiation Safety and request a survey to verify that the work area contamination is below applicable limits. If contamination is below applicable limits proceed as outlined in Section 6 Maintenance Procedures. If contamination is above the applicable limits, the IUPUI Radiation Safety staff will specify the special procedures to be followed. Once the hood has been cleared for service, Radiation Safety staff will inform CFS that the contamination has been removed and they are safe to proceed.
- **Perchloric Acid Hoods.** If work is scheduled for a perchloric acid hood the system will be tested for the presence of perchlorates by EHS staff. If perchlorates are not present or are present at acceptable levels, proceed as outlined in Section 6 Maintenance Procedures. If perchlorates are

present at greater than acceptable levels, EHS will work with CFS to modify the procedure to stabilize the perchlorates.

- **Biological Safety Cabinets.** CFS personnel must not work inside contaminated spaces of a biological safety cabinet such as the plenum, blower, or high efficiency particulate air filter (HEPA) compartment, CFS personnel should contact the IUPUI Biological Safety Manager at 274-2830 if requested to service a biological safety cabinet
- **Heat Recovery Coils.** Work to be scheduled for heat recovery coils should follow the guidelines as outlined in Section 6 Maintenance Procedures. If the heat recovery coil work involves interrupting/reducing airflow to exhaust systems servicing research facilities, the applicable procedures as outlined in Section 4 Procedures for Servicing a Dedicated Exhaust System Fan and Section 5 Procedures for a Shutdown of Multiple Chemical fume hoods shall be followed. Prefilters must be carefully removed and sealed in heavy polyethylene bags.

3. Procedures for Servicing a Chemical Fume Hood

- When a chemical fume hood is suspected of not functioning properly, the CFS office should be notified immediately at 278-1900. In order to avoid inadvertent use of the chemical fume hood, CFS will post a Shut Down Notice on the sash of the fume hood. The notice should be posted in the lower, center area of the sash so that it is easily visible.

- It is the responsibility of the laboratory personnel and/or PI to ensure that the chemical fume hood is prepared prior to maintenance by CFS. If work by CFS is required to be performed on the inside of the chemical fume hood, the laboratory personnel and/or PI must ensure the removal of all hazardous materials and equipment. If necessary, the laboratory personnel and/or PI are responsible for the decontamination of the interior of the chemical fume hood. All residues must be cleaned from the walls, the work surface, and the sash of the chemical fume hood with an appropriate solvent or cleaning solution. EHS (274-2005) may be consulted regarding appropriate decontamination procedures.
- If work is required in the hood CFS personnel will verify that all chemicals have been removed from the hood and equipment secured inside the hood before they begin work inside of the hood. The laboratory personnel

and/or PI will complete the Laboratory Personnel checklist found on the Shut Down Notice a minimum of 48 hours before work begins.

- Once the service is completed, EHS personnel will perform an airflow check with a calibrated (e.g., Alnor) hand-held portable meter to confirm that the chemical fume hood is functioning properly (currently the airflow check by EHS is not conducted for fan belt replacements or filter changes). If the chemical fume hood is functioning within the campus guidelines, the Shut Down Notice will be removed and a new chemical fume hood inspection sticker will be applied by EHS.
- If the chemical fume hood repair is determined to be beyond the scope of services available through CFS or if the airflow check indicates inadequate airflow, the Shut Down Notice will be updated to reflect the new maintenance schedule and once again be posted on the chemical fume hood. It is CFS's responsibility to follow-up with the laboratory personnel and/or PI and the affected department's administration to make sure the user understands the problem identified and the options available for repair.

4. Procedures for Servicing a Dedicated Exhaust System Fan

These procedures shall be followed when a dedicated exhaust fan serves a chemical fume hood or a small number of ganged chemical fume hoods **within one laboratory**.

- CFS will communicate to the laboratory personnel and/or PI the need for service and the duration of the fan shut down and enter a shut down notice into the system.
- CFS will obtain permission to shut down the chemical fume hood(s) and/or the local exhaust system at an agreed upon date and time.
- Except for emergency situations, CFS personnel will post the Shut Down Notice on the affected chemical fume hood(s) a minimum of three days prior to the scheduled shutdown. The notice should be posted in the lower, center area of the sash so that it is easily visible. The affected hood(s) will be out of service during the period indicated on the notice regardless of whether or not the fan is actually operating.
- The laboratory supervisor and/or PI must ensure that hazardous materials have been secured, the sash remains closed and no

operations/experiments, including closed systems, shall be conducted in the chemical fume hood(s) for the duration of the maintenance as indicated on the posted notice.

- CFS personnel will verify that all chemicals and equipment have been secured or removed from the hood and the Laboratory Personnel section of the Shut Down Notice has been completed before maintenance work begins.
- If the fan to be worked on is located near hood exhaust stacks, which do not have a 7 to 10 ft. extension, those fans must also be turned off. If this is not possible, CFS personnel must wear an appropriate respirator and safety goggles or PAPR as recommended by EHS.
- Once the service is completed, EHS personnel will perform an airflow check with a calibrated (e.g., Alnor) hand-held portable meter to confirm that the chemical fume hood is functioning properly (currently the airflow check by EHS is not conducted for fan belt replacements and filter changes). If the chemical fume hood is functioning within the campus guidelines, the "Shut Down Notice" will be removed and a new chemical fume hood inspection sticker will be applied by EHS.
- If the airflow confirmation indicates that there is inadequate airflow, the Shut Down Notice will be updated to reflect the new maintenance schedule and remain in place on the chemical fume hood. It is CFS's responsibility to follow-up with the laboratory supervisor and/or PI and the affected department's administration to make sure the user understands the problem identified and the options available for repair.
- Any questions should be directed to the CFS personnel listed on the notice at the number provided.

5. Procedures for a Shutdown of Multiple Chemical Fume Hoods

When maintenance work on a chemical fume hood fan is required, it may be necessary to schedule a shutdown of an entire bank of hoods.

- CFS will contact and communicate with the administration of the affected department(s) to confirm shutdown dates and times and enter a shut down notice into the system.
- The department administration will notify the affected researchers of the need for the fan maintenance and the date and time the fan maintenance will occur.

- Except for emergency situations, CFS personnel will post the Shut Down Notice on the affected chemical fume hood(s) a minimum of three days prior to the scheduled shutdown. The notice should be posted in the lower, center area of the sash so that it is easily visible. The affected hood(s) will be out of service during the period indicated on the notice regardless of whether or not the fan is actually operating.
- For fume hoods posted with the Shut Down Notice the laboratory personnel and/or PI must ensure that hazardous materials have been secured, the sash remains closed and no operations/experiments, including closed systems, shall be conducted in the chemical fume hood for the duration of the maintenance as indicated on the posted notice.
- CFS personnel will verify that all chemicals and equipment have been secured or removed from the hood and the Laboratory Personnel section of the Shut Down Notice has been completed before maintenance work begins.
- If the fan to be worked on is located near hood exhaust stacks, which do not have a 7 to 10 ft. extension, those fans must also be turned off. If this is not possible, CFS personnel must wear an appropriate respirator and safety goggles or PAPR as recommended by EHS.
- Once the service is completed, EHS personnel will perform an airflow check with a calibrated (e.g., Alnor) hand-held portable meter to confirm that the chemical fume hood is functioning properly (currently the airflow check by EHS is not conducted for fan belt replacements). If the chemical fume hood is functioning within the campus guidelines, the Shut Down Notice will be removed and a new chemical fume hood inspection sticker will be applied by EHS.
- If the airflow confirmation indicates that there is inadequate airflow, the Shut Down Notice will remain in place on the affected chemical fume hood. It is CFS's responsibility to follow-up with the laboratory supervisor and the affected department's administration to make sure the user understands the problem identified and the options available for repair.
- Any questions should be directed to the CFS personnel listed on the notice at the number provided.

6. Maintenance Procedures

- Disposable nitrile gloves, chemical splash goggles and chemical resistant coveralls (Tyvek™) should be worn if there is a potential for contact with internal chemical fume hood/local exhaust components. Where exhaust

systems are suspected of being pressurized an appropriate respirator and chemical splash goggles or PAPR shall be worn to prevent exposure to potentially contaminated exhaust air.

- If cleaning internal chemical fume hood surfaces with all-purpose cleaners (e.g., Soilax®, TSP) wear long length chemical resistant reusable gloves with folded cuffs, chemical splash goggles and chemical resistant coveralls (Tyvek™).
- When working around sharp objects like sheet metal, wear appropriate outer work gloves in addition to inner disposable nitrile gloves. If the outer work gloves are suspected of being contaminated they shall be disposed of at the completion of each workday.
- When performing work near hood exhaust stacks, which do not have a 7 to 10 ft. extension, arrangements should be made to shut down the associated exhaust fans for the duration of the work. If this is not possible, CFS personnel must wear an appropriate respirator and safety goggles or PAPR as recommended by EHS.
- Do not eat, drink, or apply cosmetics or medication while in the laboratory.
- Do not touch, move or handle containers of any chemicals or materials in a laboratory. If containers or equipment need to be moved, ask the laboratory supervisor to relocate them.
- After work is completed, the nitrile gloves should be discarded and hands should be washed with soap and water.
- Personal hygiene is important. Hands should always be washed with soap and water at the completion of any work.

7. Unscheduled Shut Down

- CFS personnel will post the Emergency Shut Down notice and close the sash on all affected fume hoods when an unscheduled shut down occurs.
- The procedures outlined in this policy will be followed when completing the repairs.

IUPUI LABORATORY DECOMMISSIONING POLICY

Subject: Policy for the Decommissioning or Relocation of Laboratories
Effective Date: August 28, 2009
Approved: IUPUI Laboratory Safety Committee

PURPOSE AND BACKGROUND:

This policy has been created to ensure the proper decommissioning or relocation of laboratories on campus in order to minimize hazards to University employees, to maintain compliance with all applicable federal, state and local regulations, and to promote environmental stewardship. This is not a policy for radiological decommissioning of laboratories which must be performed by the IUPUI Radiation Safety Department.

SCOPE:

The program applies to all University research laboratories and any auxiliary laboratory support areas. The program lists the requirements for the removal of all chemical, physical, biological, and radiological hazards associated with research from the aforementioned spaces when the area is being vacated for any of the following reasons:

- The principal investigator is leaving IUPUI;
- The principal investigator is relocating to a new laboratory at IUPUI;
- The space is being vacated for renovations; or
- The space is scheduled for demolition.

POLICY:

Authority and Responsibility

Environmental Health and Safety is responsible for:

1. Developing and implementing a Laboratory Decommissioning and Relocation Policy;
2. Conducting post-inspections of the space to ensure the area is free of recognized hazards;

Laboratory Directors or Principal Investigators are responsible for:

1. Notifying Environmental Health and Safety 30 days before vacating the space;

2. Complying with all aspects of the Laboratory Decommissioning and Relocation Policy;
3. Providing the arrangements for the relocation or disposal of hazardous materials;
4. Notifying EHS after all activities have occurred for a final inspection of the area.

Departments are responsible for:

1. Ensuring that the principal investigator complies with the procedures in this policy;
2. Assuming the responsibilities of the Laboratory Director or Principal Investigator if the area is a shared space such as a cold room or teaching lab.
3. Procuring the cost of the relocation or disposal of hazardous materials if the principal investigator vacates the laboratory without complying with this policy

Notification

Environmental Health and Safety shall be notified at least 30 days prior to vacating the laboratory and any laboratory support areas and before commencing any evacuating activities. Environmental Health and Safety will conduct a pre-inspection of the space with the principal investigator to identify all chemical, physical, biological and radiological hazards within the space. If any radiological hazards are identified or are suspected to be associated with the space, the Radiation Safety Office shall also be notified at 274-4797 by the laboratory director or principal investigator.

If a vacated laboratory or auxiliary laboratory support area is being occupied by a new principal investigator, it is the responsibility of the new principal investigator to ensure the space is free of recognized hazards prior to occupying the space. Environmental Health and Safety shall be contacted for assistance. If a vacated laboratory or laboratory support area has not been decommissioned properly, and becomes occupied, all materials found within the laboratory shall become the responsibility of the new principal investigator.

General Housekeeping

All general refuse shall be removed from the space including empty containers, papers, and disposable materials. All non-hazardous materials may be disposed of as general waste. All surfaces, including bench tops and fume hoods shall be washed down with warm, soapy water after all garbage and debris has been removed.

Any broken glass or unwanted glassware shall be disposed of in a cardboard box or other rigid, puncture-resistant containers designated for glass. The container shall taped shut at which point it can be removed from the space by building services.

Any sharps such as needles or razor blades shall be disposed of in an approved sharps-container and shall be removed from the space. The sharps container must be autoclaved prior to disposal if they are contaminated with biological materials.

Chemical Hazards

All chemical waste shall be removed from the space prior to vacating the space. Ensure that all containers of chemicals are securely closed and labeled with the name of the chemical. Chemical wastes are collected for disposal, not sewered or placed in the trash. Follow all IUPUI waste disposal guidelines.

All refrigerators, freezers, fume hoods, bench tops and storage cabinets must be checked for chemical containers.

Disposal of hazardous chemicals into sinks, drains, commodes or other sewage disposal channels is **STRICTLY PROHIBITED**. Empty containers may be disposed of as general waste.

Usable chemicals are transferred to another party who is willing to assume responsibility for them. If a new user cannot be found, the materials are disposed through the EHS hazardous waste program.

Detailed instructions for chemical disposal are available in the IUPUI Waste Disposal Guidelines. 30 days advance notice is required for 50 containers or more. Chemical pickup should be completed before the laboratory is vacated. Waste collection will take at least a week after notification that waste is ready for pickup.

Check chemical containers for expiration dates and signs of damage, corrosion or crystallization. Any expired chemicals or any chemical containers exhibiting damage, corrosion or crystallization shall be disposed of as chemical waste and shall not be relocated to a new location.

Any peroxide-forming materials within the space shall be disposed of as chemical waste and shall not be relocated to a new location if the container has been opened and is more than six months old, or if it has not been opened and is more than one year old. Dried containers of picric acid or picrates shall not be moved and shall be disposed of as hazardous waste. Environmental Health and Safety (EHS) shall be notified if perchloric acid has been use within the space or in a fume hood so that the space may be tested for perchlorates.

Hazardous chemicals that will be relocated to a new space on campus shall be packaged and transported by the University's hazardous materials contractor or transported by laboratory personnel if approved by EHS according to IUPUI Chemical Move Guidelines. All chemicals shall be moved during normal business hours (8:00 a.m. and 4:30 p.m. Monday through Friday) so that in the event of an accident or spill, EHS can easily respond. Equipment and other, non-hazardous materials may be moved after hours or on the weekends. Laboratory personnel shall be present at the time that chemicals will be relocated to the new space.

When transporting chemicals, refer to the IUPUI **Chemical Move Guidelines**.

Controlled Substances

Controlled substance permits are issued by the US Drug Enforcement Agency (DEA) and are issued to individual researchers. There is no central record of permit holders.

Abandonment of a controlled substance is a violation of the DEA permit under which it was held.

Permission to transfer ownership of a controlled substance to another individual must be received from DEA.

EHS is notified if controlled substances for which the licensee is unknown are found.

Physical Hazards

All recognized physical hazards that exist within the space that are not considered to be a part of the space shall be removed prior to vacating the space. Such hazards include, but are not limited to: items, objects or equipment that may cause slips, trips, falls, heat stress, cold stress, high noise, vibrations, and any bodily harm or damage. All laboratory specific research apparatus must be dismantled, decontaminated and removed from the space.

Refrigerators, Freezers and Equipment

Refrigerators shall be emptied and contents segregated into hazard classes before removing from the space. A cooler with dry ice may be used to move items that must be refrigerated. Freezers may be removed with the contents inside as long as they do not contain breakable containers, are labeled as to what is inside the freezer, and are locked and securely strapped shut.

All laboratory equipment contaminated or potentially contaminated with chemicals or biological materials shall be decontaminated before removal from the space. Equipment shall have chemicals safely removed, drained or discharged from the equipment.

Biological materials shall be removed from the equipment. Disinfect surfaces that may be contaminated with biological agents by cleaning with a bleach and water solution consisting of one part of bleach to ten (1:10) parts of water. As a final step, wipe equipment down with a 70% alcohol solution.

This equipment includes, but is not limited to:

- Centrifuges;
- Glassware;
- Plastic ware;
- Glove boxes;
- Flammable cabinets;
- Corrosive cabinets;
- Water baths;
- Refrigerators;
- Ovens;
- Microfuges;
- Incubators;
- Microwave ovens;
- Shakers;
- Vacuum pumps;
- Compressors.

If typical decontamination procedures may damage the equipment or cause a safety issue, please refer to the manufacturer's recommendations for decontamination of the equipment.

Laboratory equipment to be left for the next occupant is cleaned, decontaminated, and tagged before the laboratory is vacated.

Compressed Gasses

Compressed gas cylinders and dewars shall be properly secured and capped when they are transported. Cylinders shall be transported in an upright position in an approved cylinder cart. Never move a cylinder by rolling it across the floor. Do not

leave a cylinder unattended in the corridor. Never drop cylinders or bang them against each other or another object. Empty cylinders shall be labeled "empty".

Cylinders shall be disconnected, their caps replaced and the cylinders returned to suppliers or relocated.

Non-returnable cylinders (i.e., lecture bottles) are manifested and packed as chemical waste.

Biological Hazards

All biohazardous materials (materials containing or previously containing microorganisms, toxins, and allergens derived from those organisms, plants and animals) shall be removed from the space.

If the space is a BL2 lab or higher, the Biological Safety Manager shall also be notified at 274-2830 by the laboratory director, principal investigator or department representative.

Clean all surfaces that may be contaminated with biological agents with warm, soapy water. Disinfect surfaces that may be contaminated with biological agents with a bleach and water solution consisting of one part of bleach to ten (1:10) parts of water. As a final step, wipe surfaces down with a 70% alcohol solution.

Autoclave all potentially infectious waste and dispose of according to the procedures for your biosafety level and remove all media and supplies from drawers, shelves, and cabinets.

Biological Safety Cabinets require professional decontamination prior to removing and require re-certification if it is being relocated.

Radiological Hazards

If any radiological hazards are identified or are suspected to be associated with the space, the Radiation Safety Office shall be notified at 274-4797 by the laboratory director, principal investigator or department representative.

Miscellaneous Hazards

Certain laboratory equipment and apparatuses may contain materials or chemicals which are potentially harmful to human health or the environment. These may include:

- Asbestos (e.g., autoclaves, ovens, gloves, curtains, hot plates);
- Mercury (e.g., manometers, thermometers, barometers, silent switches);
- PCB's (e.g., batteries, batteries supplies, high voltage systems, capacitors, pump oils);
- Acids (e.g., batteries); and
- Solvents (e.g., degreasing equipment).

Notify EHS if you have knowledge or suspect equipment to have any of these materials.

Chemical Emergencies

The IUPUI Emergency Dispatch shall be notified immediately upon an emergency incident by dialing 911 from a campus phone or 274-7911 from a non-campus phone.

Refer to the IUPUI Emergency Procedures flipchart for instructions on how to respond to a chemical spill. If a chemical spill occurs, contact the IUPUI Emergency Dispatch immediately by dialing 911 from a campus phone or 274-7911 from a non-campus phone.

NONCOMPLIANCE/PENALTIES:

The Department of Environmental Health and Safety may, at its discretion, refer costs incurred from the disposal of wastes generated by actions contrary to the principles of this policy back to the producing or generating department.

Staff, faculty, students and guests of the University whose willful actions violate existing federal and state regulation may be held criminally and civilly liable for their actions.

In the event the University is cited and fined by federal, state or local regulatory agencies for actions or activities contrary to applicable regulations, the department(s) involved in the citation may be accountable for payment of the issued fine.

In addition, the University may initiate disciplinary actions, up to and including dismissal, against any staff or faculty found to be in violation of this policy.

PROGRAM OVERSIGHT AND EMPLOYEE ASSISTANCE:

The Department of Environmental Health and Safety will serve as a technical resource for the implementation of this program

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IUPUI GLOVE DISPOSAL POLICY

Subject: Glove Disposal in Research
Effective Date: May 28, 2010
Approved: IUPUI Laboratory Safety Committee

PURPOSE AND BACKGROUND:

Appropriate gloves are required PPE when handling hazardous materials. The proper disposal of used gloves in academic research areas and/or laboratories is also essential. This policy has been written to enforce the proper disposal of gloves as gloves used for chemical manipulations are disposed in a different manner than those gloves used for manipulation of biological agents.

SCOPE:

By the adoption of this policy, Administration shares this commitment with all staff, faculty, students and guests of the University community.

POLICY:

1) Gloves used when handling the following material must be autoclaved prior to disposal if they have not been used in combination with hazardous agents such as mutagens, teratogens, carcinogens, radioactive materials or chemicals with a high level of acute toxicity:

   a) Any material containing or contaminated with human pathogens

   b) Any material containing or contaminated with animal pathogens

   c) Any material containing or contaminated with plant pathogens

   d) Any material containing or contaminated with recombinant DNA or recombinant organism: NIH Guidelines Appendix G-II-A-1-c (BL1), G-II-B-1-c (BL2), G-II-C-1-b (BL3). All wastes from laboratories and animal rooms are appropriately decontaminated before disposal.

   e) Any material containing or contaminated with any other potentially infectious material: IC 16-41-16 – Communicable Disease: Treatment of Infectious Waste; Biosafety in Microbiological and Biomedical Laboratories, 5th Ed., Section IV-C-4-c (BL1, BL2, BL2), Dispose of used gloves with other contaminated laboratory waste.

f) Gloves worn while working inside of a biosafety cabinet.

2) Gloves used in laboratories while handling mixed wastes such as hazardous chemicals or radioactive materials in combination with the materials listed above, or any other material that is not listed above must be disposed of without autoclaving.

3) All gloves must be disposed of prior to leaving the laboratory if no materials are being transported outside of the laboratory. If materials requiring gloves are transported outside of the laboratory then a glove may be worn on the hand carrying the material and the other hand shall be glove free to open doors or touch areas outside of the laboratory with the ungloved hand.

4) A thorough hand washing shall be performed once gloves are removed before personnel leave the laboratory.

NONCOMPLIANCE/PENALTIES:

The Department of Environmental Health and Safety may, at its discretion, refer costs incurred from the disposal of wastes generated by actions contrary to the principles of this policy back to the producing or generating department.

Staff, faculty, students and guests of the University whose willful actions violate existing federal and state regulation may be held criminally and civilly liable for their actions.

In the event the University is cited and fined by federal, state or local regulatory agencies for actions or activities contrary to applicable regulations, the department(s) involved in the citation may be accountable for payment of the issued fine.

In addition, the University may initiate disciplinary actions, up to and including dismissal, against any staff or faculty found to be in violation of this policy.

PROGRAM OVERSIGHT AND EMPLOYEE ASSISTANCE:

The Department of Environmental Health and Safety will serve as a technical resource for the implementation of this program. The Department will also serve to oversee the development and implementation of mercury educational materials as needed.

IUPUI POLICY FOR THE SAFE USE OF GAS CARTRIDGE BUNSEN BURNERS

Subject: Safe Use of Gas Cartridge Bunsen Burners
Effective Date: n
Approved: IUPUI Laboratory Safety Committee

PURPOSE AND BACKGROUND:

Bunsen burners and compressed flammable gas cartridges present hazards to the IUPUI community. Bunsen burners produce an open flame and burn at a high temperature, and as a result, there is potential for an accident to occur. Flammable gas cartridges contain flammable gas under pressure and have the potential for explosion and/or fire. The following policy was created to ensure the proper use and storage of these devices.

SCOPE:

This policy applies to all University research laboratories and any auxiliary laboratory support areas. This policy must be followed by all staff, faculty, students and guests of the University community.

POLICY:

Authority and Responsibility

Environmental Health and Safety is responsible for:

3. Developing and implementing a gas cartridge bunsen burner safety policy;
4. Assessing the safe use of gas cartridge bunsen burners and proper storage of unused gas cartridges during annual laboratory safety inspections.

Laboratory Directors or Principal Investigators are responsible for:

5. Complying with all aspects of the Policy for the Safe Use of Gas Cartridge Bunsen Burners;
6. Ensuring all staff, faculty, students and guests of the University comply with all aspects of the Policy for the Safe Use of Gas Cartridge Bunsen Burners.

Departments are responsible for:

4. Ensuring that the principal investigator complies with the procedures in this policy;
5. Assuming the responsibilities of the Laboratory Director or Principal Investigator if the area is a shared space such as a cold room or teaching lab.

Burner Safety

a) Keep open flame away from any overhead shelving, equipment or light fixtures.

b) Ensure all papers, notebooks, combustible materials and all flammable chemicals are removed from the area where the burner will be used.

c) All long hair, dangling jewelry, or loose clothing must be tied back or confined when using an open flame.

d) Do not use an open flame within 5 feet of flammable chemicals.

e) Notify laboratory personnel present in the lab that the burner will be in use.

f) Follow all manufacturer instructions for the use of the burner.

g) Allow the burner to cool before handling.

h) Do not use bunsen burners or open flames in biosafety cabinets

NONCOMPLIANCE/PENALTIES:

Staff, faculty, students and guests of the University whose willful actions violate existing federal and state regulation may be held criminally and civilly liable for their actions.

In the event the University is cited and fined by federal, state or local regulatory agencies for actions or activities contrary to the procedures in this policy, the department(s) involved in the citation may be accountable for payment of the issued fine.

In addition, the University may initiate disciplinary actions, up to and including dismissal, against any staff or faculty found to be in violation of this policy.

PROGRAM OVERSIGHT AND EMPLOYEE ASSISTANCE:

The Department of Environmental Health and Safety will serve as a technical resource for the implementation of this program. The Department will also serve to oversee the development and implementation of any educational materials as needed.

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APPENDIX B: LIMITS FOR AIR CONTAMINANTS

29 CFR 1910.1000(f)(4)
TABLES Z-1, Z-2, AND Z-3

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TABLE Z-1 LIMITS FOR AIR CONTAMINANTS

NOTE: Because of the length of the table, explanatory Footnotes applicable to all substances are given below as well as at the end of the table. Footnotes specific only to a limited number of substances are also shown within the table.

Footnote(1) The PELs are 8-hour TWAs unless otherwise noted; a (C) designation denotes a ceiling limit. They are to be determined from breathing-zone air samples.

Footnote(a) Parts of vapor or gas per million parts of contaminated air by volume at 25 degrees C and 760 torr.

Footnote(b) Milligrams of substance per cubic meter of air. When entry is in this column only, the value is exact; when listed with a ppm entry, it is approximate.

Footnote(c) The CAS number is for information only. Enforcement is based on the substance name. For an entry covering more than one metal compound measured as the metal, the CAS number for the metal is given - not CAS numbers for the individual compounds.

Footnote(d) The final benzene standard in 1910.1028 applies to all occupational exposures to benzene except in some circumstances the distribution and sale of fuels, sealed containers and pipelines, coke production, oil and gas drilling and production, natural gas processing, and the percentage exclusion for liquid mixtures; for the excepted subsegments, the benzene limits in Table Z-2 apply. See 1910.1028 for specific circumstances.

Footnote(e) This 8-hour TWA applies to respirable dust as measured by a vertical elutriator cotton dust sampler or equivalent instrument. The time-weighted average applies to the cotton waste processing operations of waste recycling (sorting, blending, cleaning and willowing) and garnetting. See also 1910.1043 for cotton dust limits applicable to other sectors.

Footnote(f) All inert or nuisance dusts, whether mineral, inorganic, or organic, not listed specifically by substance name are covered by the Particulates Not Otherwise Regulated (PNOR) limit which is the same as the inert or nuisance dust limit of Table Z-3.

Footnote(2) See Table Z-2.

Footnote(3) See Table Z-3

Footnote(4) Varies with compound.

Footnote(5) See Table Z-2 for the exposure limits for any operations or sectors where the exposure limits in 1910.1026 are stayed or are otherwise not in effect.

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TABLE Z-1. - LIMITS FOR AIR CONTAMINANTS

Substance	CAS No. (c)	ppm (a)(1)	mg/m(3) (b)(1)	Skin designation
Acetaldehyde.....	75-07-0	200	360	
Acetic acid.....	64-19-7	10	25	
Acetic anhydride.....	108-24-7	5	20	
Acetone.....	67-64-1	1000	2400	
Acetonitrile.....	75-05-8	40	70	
2-Acetylaminofluorene; see 1910.1014.....	53-96-3			
Acetylene dichloride; see 1,2-Dichloroethylene.				
Acetylene tetrabromide.	79-27-6	1	14	
Acrolein.....	107-02-8	0.1	0.25	
Acrylamide.....	79-06-1	.....	0.3	X
Acrylonitrile; see 1910.1045.....	107-13-1			
Aldrin.....	309-00-2	.....	0.25	X
Allyl alcohol.....	107-18-6	2	5	X
Allyl chloride.....	107-05-1	1	3	
Allyl glycidyl ether... (AGE).....	106-92-3	(C)10	(C)45	
Allyl propyl disulfide.	2179-59-1	2	12	
alpha-Alumina.....	1344-28-1			
Total dust.....		.....	15	
Respirable fraction..		.....	5	
Aluminum Metal (as Al).	7429-90-5			
Total dust.....		.....	15	
Respirable fraction..		.....	5	
4-Aminodiphenyl; see 1910.1011.....	92-67-1			
2-Aminoethanol; see Ethanolamine.....				
2-Aminopyridine.....	504-29-0	0.5	2	
Ammonia.....	7664-41-7	50	35	
Ammonium sulfamate.....	7773-06-0			
Total dust.....		.....	15	
Respirable fraction..		.....	5	
n-Amyl acetate.....	628-63-7	100	525	
sec-Amyl acetate.....	626-38-0	125	650	
Aniline and homologs...	62-53-3	5	19	X
Anisidine (o-,p-isomers).....	29191-52-4	.....	0.5	X
Antimony and compounds (as Sb).....	7440-36-0	.....	0.5	
ANTU (alpha Naphthylthiourea)....	86-88-4	.....	0.3	
Arsenic, inorganic compounds (as As); see 1910.1018.....	7440-38-2			
Arsenic, organic compounds (as As)....	7440-38-2	.....	0.5	
Arsine.....	7784-42-1	0.05	0.2	
Asbestos; see 1910.1001.....	(4)			
Azinphos-methyl.....	86-50-0	.....	0.2	X
Barium, soluble compounds (as Ba)....	7440-39-3	.....	0.5	
Barium sulfate.....	7727-43-7			
Total dust.....		.....	15	
Respirable fraction..		.....	5	

Benomyl.....	17804-35-2			
Total dust.....		.....	15	
Respirable fraction..		.....	5	
Benzene; See 1910.1028. See Table Z-2 for the limits applicable in the operations or sectors excluded in 1910.1028(d)	71-43-2			
Benzidine; See 1910.1010.....	92-87-5			
p-Benzoquinone; see Quinone.				
Benzo(a)pyrene; see Coal tar pitch volatiles.....				
Benzoyl peroxide.....	94-36-0	.....	5	
Benzyl chloride.....	100-44-7	1	5	
Beryllium and beryllium compounds (as Be).....	7440-41-7		(2)	
Biphenyl; see Diphenyl.				
Bismuth telluride, Undoped.....	1304-82-1			
Total dust.....		.....	15	
Respirable fraction..		.....	5	
Boron oxide.....	1303-86-2			
Total dust.....		.....	15	
Boron trifluoride.....	7637-07-2	(C)1	(C)3	
Bromine.....	7726-95-6	0.1	0.7	
Bromoform.....	75-25-2	0.5	5	X
Butadiene (1,3-Butadiene); See 29 CFR 1910.1051; 29 CFR 1910.19(1)....	106-99-0	1 ppm/5 ppm STEL		
Butanethiol; see Butyl mercaptan.				
2-Butanone (Methyl ethyl ketone)	78-93-3	200	590	
2-Butoxyethanol.....	111-76-2	50	240	X
n-Butyl-acetate.....	123-86-4	150	710	
sec-Butyl acetate.....	105-46-4	200	950	
tert-Butyl-acetate.....	540-88-5	200	950	
n-Butyl alcohol.....	71-36-3	100	300	
sec-Butyl alcohol.....	78-92-2	150	450	
tert-Butyl alcohol.....	75-65-0	100	300	
Butylamine.....	109-73-9	(C)5	(C)15	X
tert-Butyl chromate (as CrO(3))..... see 1910.1026	1189-85-1			
n-Butyl glycidyl ether (BGE).....	2426-08-6	50	270	
Butyl mercaptan.....	109-79-5	10	35	
p-tert-Butyltoluene....	98-51-1	10	60	
Cadmium (as Cd); see 1910.1027.....	7440-43-9			
Calcium Carbonate.....	1317-65-3			
Total dust.....		.....	15	
Respirable fraction..		.....	5	
Calcium hydroxide.....	1305-62-0			
Total dust.....		.....	15	
Respirable fraction..		.....	5	
Calcium oxide.....	1305-78-8	.....	5	
Calcium silicate.....	1344-95-2			
Total dust.....		.....	15	
Respirable fraction..		.....	5	
Calcium sulfate.....	7778-18-9			
Total dust.....		.....	15	
Respirable fraction..		.....	5	
Camphor, synthetic.....	76-22-2	.....	2	

Carbaryl (Sevin).....	63-25-2	.....	5	
Carbon black.....	1333-86-4	.....	3.5	
Carbon dioxide.....	124-38-9	5000	9000	
Carbon disulfide.....	75-15-0		(2)	
Carbon monoxide.....	630-08-0	50	55	
Carbon tetrachloride...	56-23-5		(2)	
Cellulose.....	9004-34-6			
Total dust.....		.....	15	
Respirable fraction..		.....	5	
Chlordane.....	57-74-9	.....	0.5	X
Chlorinated camphene...	8001-35-2	.....	0.5	X
Chlorinated diphenyl oxide.....	55720-99-5	.....	0.5	
Chlorine.....	7782-50-5	(C)1	(C)3	
Chlorine dioxide.....	10049-04-4	0.1	0.3	
Chlorine trifluoride...	7790-91-2	(C)0.1	(C)0.4	
Chloroacetaldehyde.....	107-20-0	(C)1	(C)3	
a-Chloroacetophenone (Phenacyl chloride)..	532-27-4	0.05	0.3	
Chlorobenzene.....	108-90-7	75	350	
o-Chlorobenzylidene malononitrile.....	2698-41-1	0.05	0.4	
Chlorobromomethane.....	74-97-5	200	1050	
2-Chloro-1,3-butadiene; See beta-Chloroprene.				
Chlorodiphenyl (42% Chlorine)(PCB)..	53469-21-9	.....	1	X
Chlorodiphenyl (54% Chlorine)(PCB)..	11097-69-1	.....	0.5	X
1-Chloro-2, 3-epoxypropane; See Epichlorohydrin.				
2-Chloroethanol; See Ethylene chlorohydrin				
Chloroethylene; See Vinyl chloride.				
Chloroform (Trichloromethane)...	67-66-3	(C)50	(C)240	
bis(Chloromethyl) ether; see 1910.1008.	542-88-1			
Chloromethyl methyl ether; see 1910.1006.	107-30-2			
1-Chloro-1-nitropropane	600-25-9	20	100	
Chloropicrin.....	76-06-2	0.1	0.7	
beta-Chloroprene.....	126-99-8	25	90	X
2-Chloro-6 (trichloromethyl) pyridine.....	1929-82-4			
Total dust.....		.....	15	
Respirable fraction..		.....	5	
Chromic acid and chromates (as CrO(3))	(4)		(2)	
Chromium (II) compounds (as Cr).....	7440-47-3	.....	0.5	
Chromium (III) compounds (as Cr)....	7440-47-3	.....	0.5	
Chromium (VI) compounds See 1910.1026(5)				
Chromium metal and insol. salts (as Cr).	7440-47-3	.....	1	
Chrysene; see Coal tar pitch volatiles.....				
Clopidol.....	2971-90-6			
Total dust.....		.....	15	
Respirable fraction..		.....	5	
Coal dust (less than 5% SiO(2)), respirable fraction..			(3)	
Coal dust (greater than or equal to 5% SiO(2)), respirable				

fraction.....			(3)	
Coal tar pitch volatiles (benzene soluble fraction), anthracene, BaP, phenanthrene, acridine, chrysene, pyrene.....	65966-93-2	.....	0.2	
Cobalt metal, dust, and fume (as Co).....	7440-48-4	.....	0.1	
Coke oven emissions; see 1910.1029.....				
Copper.....	7440-50-8			
Fume (as Cu).....		.....	0.1	
Dusts and mists (as Cu).....		.....	1	
Cotton dust (e), see 1910.1043.....		.....	1	
Crag herbicide (Sesone)	136-78-7			
Total dust.....		.....	15	
Respirable fraction..		.....	5	
Cresol, all isomers....	1319-77-3	5	22	X
Crotonaldehyde.....	123-73-9 4170-30-3	2	6	
Cumene.....	98-82-8	50	245	X
Cyanides (as CN).....	(4)	.....	5	X
Cyclohexane.....	110-82-7	300	1050	
Cyclohexanol.....	108-93-0	50	200	
Cyclohexanone.....	108-94-1	50	200	
Cyclohexene.....	110-83-8	300	1015	
Cyclopentadiene.....	542-92-7	75	200	
2,4-D (Dichlorophen-oxyacetic acid).....	94-75-7	.....	10	
Decaborane.....	17702-41-9	0.05	0.3	X
Demeton (Systox).....	8065-48-3	.....	0.1	X
Diacetone alcohol (4-Hydroxy-4-methyl-2-pentanone).....	123-42-2	50	240	
1,2-Diaminoethane; see Ethylenediamine..				
Diazomethane.....	334-88-3	0.2	0.4	
Diborane.....	19287-45-7	0.1	0.1	
1,2-Dibromo-3-chloropropane (DBCP); see 1910.1044.....	96-12-8			
1,2-Dibromoethane; see Ethylene dibromide...				
Dibutyl phosphate.....	107-66-4	1	5	
Dibutyl phthalate.....	84-74-2	.....	5	
o-Dichlorobenzene.....	95-50-1	(C)50	(C)300	
p-Dichlorobenzene.....	106-46-7	75	450	
3,3'-Dichlorobenzidine; see 1910.1007.....	91-94-1			
Dichlorodifluoromethane	75-71-8	1000	4950	
1,3-Dichloro-5,5-dimethyl hydantoin.	118-52-5	.....	0.2	
Dichlorodiphenyltri-chloroethane (DDT)...	50-29-3	.....	1	X
1,1-Dichloroethane.....	75-34-3	100	400	
1,2-Dichloroethane; see Ethylene dichloride..				
1,2-Dichloroethylene...	540-59-0	200	790	
Dichloroethyl ether....	111-44-4	(C)15	(C)90	X
Dichloromethane; see Methylene chloride...				
Dichloromonofluoro-methane.....	75-43-4	1000	4200	
1,1-Dichloro-1-nitroethane.....	594-72-9	(C)10	(C)60	
1,2-Dichloropropane; see				

Propylene dichloride.				
Dichlorotetrafluoro-ethane.....	76-14-2	1000	7000	
Dichlorvos (DDVP).....	62-73-7	.....	1	X
Dicyclopentadienyl iron	102-54-5			
Total dust.....		.....	15	
Respirable fraction..		.....	5	
Dieldrin.....	60-57-1	.....	0.25	X
Diethylamine.....	109-89-7	25	75	
2-Diethylaminoethanol..	100-37-8	10	50	X
Diethyl ether; see Ethyl ether.....				
Difluorodibromomethane.	75-61-6	100	860	
Diglycidyl ether (DGE).	2238-07-5	(C)0.5	(C)2.8	
Dihydroxybenzene; see Hydroquinone.....				
Diisobutyl ketone.....	108-83-8	50	290	
Diisopropylamine.....	108-18-9	5	20	X
4-Dimethylaminoazo-benzene; see 1910.1015.....	60-11-7			
Dimethoxymethane; see Methylal.....				
Dimethyl acetamide.....	127-19-5	10	35	X
Dimethylamine.....	124-40-3	10	18	
Dimethylaminobenzene; see Xylidine.....				
Dimethylaniline (N,N-Dimethylaniline)	121-69-7	5	25	X
Dimethylbenzene; see Xylene.....				
Dimethyl-1,2-dibromo-2, 2-dichloroethyl phosphate.....	300-76-5	.....	3	
Dimethylformamide.....	68-12-2	10	30	X
2,6-Dimethyl-4-heptanone; see Diisobutyl ketone....				
1,1-Dimethylhydrazine..	57-14-7	0.5	1	X
Dimethylphthalate.....	131-11-3	.....	5	
Dimethyl sulfate.....	77-78-1	1	5	X
Dinitrobenzene (all isomers).....			1	X
(ortho).....	528-29-0			
(meta).....	99-65-0			
(para).....	100-25-4			
Dinitro-o-cresol.....	534-52-1	.....	0.2	X
Dinitrotoluene.....	25321-14-6	.....	1.5	X
Dioxane (Diethylene dioxide).	123-91-1	100	360	X
Diphenyl (Biphenyl)....	92-52-4	0.2	1	
Diphenylmethane diisocyanate; see Methylene bisphenyl isocyanate.....				
Dipropylene glycol methyl ether.....	34590-94-8	100	600	X
Di-sec octyl phthalate (Di-(2-ethylhexyl) phthalate).....	117-81-7	.....	5	
Emery.....	12415-34-8			
Total dust.....		.....	15	
Respirable fraction..		.....	5	
Endrin.....	72-20-8	.....	0.1	X
Epichlorohydrin.....	106-89-8	5	19	X
EPN.....	2104-64-5	.....	0.5	X
1,2-Epoxypropane; see Propylene oxide.....				
2,3-Epoxy-1-propanol; see Glycidol.....				
Ethanethiol; see				

Ethyl mercaptan.....				
Ethanolamine.....	141-43-5	3	6	
2-Ethoxyethanol (Cellosolve).....	110-80-5	200	740	X
2-Ethoxyethyl acetate (Cellosolve acetate).	111-15-9	100	540	X
Ethyl acetate.....	141-78-6	400	1400	
Ethyl acrylate.....	140-88-5	25	100	X
Ethyl alcohol (Ethanol)	64-17-5	1000	1900	
Ethylamine.....	75-04-7	10	18	
Ethyl amyl ketone (5-Methyl-3-heptanone).....	541-85-5	25	130	
Ethyl benzene.....	100-41-4	100	435	
Ethyl bromide.....	74-96-4	200	890	
Ethyl butyl ketone (3-Heptanone).....	106-35-4	50	230	
Ethyl chloride.....	75-00-3	1000	2600	
Ethyl ether.....	60-29-7	400	1200	
Ethyl formate.....	109-94-4	100	300	
Ethyl mercaptan.....	75-08-1	(C)10	(C)25	
Ethyl silicate.....	78-10-4	100	850	
Ethylene chlorohydrin..	107-07-3	5	16	X
Ethylenediamine.....	107-15-3	10	25	
Ethylene dibromide.....	106-93-4		(2)	
Ethylene dichloride (1,2-Dichloroethane).	107-06-2		(2)	
Ethylene glycol dinitrate.....	628-96-6	(C)0.2	(C)1	X
Ethylene glycol methyl acetate; see Methyl cellosolve acetate...				
Ethyleneimine; see 1910.1012.....	151-56-4			
Ethylene oxide; see 1910.1047.....	75-21-8			
Ethylidene chloride; see 1,1-Dichlorethane				
N-Ethylmorpholine.....	100-74-3	20	94	X
Ferbam.....	14484-64-1			
Total dust.....		.....	15	
Ferrovanadium dust.....	12604-58-9	.....	1	
Fluorides (as F).....	(4)	.....	2.5	
Fluorine.....	7782-41-4	0.1	0.2	
Fluorotrichloromethane (Trichloro-fluoromethane).....	75-69-4	1000	5600	
Formaldehyde; see 1910.1048.....	50-00-0			
Formic acid.....	64-18-6	5	9	
Furfural.....	98-01-1	5	20	X
Furfuryl alcohol.....	98-00-0	50	200	
Grain dust (oat, wheat barley).....	.....	.....	10	
Glycerin (mist).....	56-81-5			
Total dust.....		.....	15	
Respirable fraction..		.....	5	
Glycidol.....	556-52-5	50	150	
Glycol monoethyl ether; see 2-Ethoxyethanol..				
Graphite, natural respirable dust.....	7782-42-5		(3)	
Graphite, synthetic....				
Total dust.....		.....	15	
Respirable Fraction..		.....	5	
Guthion; see Azinphos methyl..				
Gypsum.....	13397-24-5			
Total dust.....		.....	15	
Respirable fraction..		.....	5	
Hafnium.....	7440-58-6	.....	0.5	

Heptachlor.....	76-44-8	.....	0.5	X
Heptane (n-Heptane)....	142-82-5	500	2000	
Hexachloroethane.....	67-72-1	1	10	X
Hexachloronaphthalene..	1335-87-1	.....	0.2	X
n-Hexane.....	110-54-3	500	1800	
2-Hexanone (Methyl n-butyl ketone).....	591-78-6	100	410	
Hexone (Methyl isobutyl ketone).....	108-10-1	100	410	
sec-Hexyl acetate.....	108-84-9	50	300	
Hydrazine.....	302-01-2	1	1.3	X
Hydrogen bromide.....	10035-10-6	3	10	
Hydrogen chloride.....	7647-01-0	(C)5	(C)7	
Hydrogen cyanide.....	74-90-8	10	11	X
Hydrogen fluoride (as F).....	7664-39-3		(2)	
Hydrogen peroxide.....	7722-84-1	1	1.4	
Hydrogen selenide (as Se).....	7783-07-5	0.05	0.2	
Hydrogen sulfide.....	7783-06-4		(2)	
Hydroquinone.....	123-31-9	.....	2	
Iodine.....	7553-56-2	(C)0.1	(C)1	
Iron oxide fume.....	1309-37-1	.....	10	
Isomyl acetate.....	123-92-2	100	525	
Isomyl alcohol (primary and secondary).....	123-51-3	100	360	
Isobutyl acetate.....	110-19-0	150	700	
Isobutyl alcohol.....	78-83-1	100	300	
Isophorone.....	78-59-1	25	140	
Isopropyl acetate.....	108-21-4	250	950	
Isopropyl alcohol.....	67-63-0	400	980	
Isopropylamine.....	75-31-0	5	12	
Isopropyl ether.....	108-20-3	500	2100	
Isopropyl glycidyl ether (IGE).....	4016-14-2	50	240	
Kaolin.....	1332-58-7			
Total dust.....		.....	15	
Respirable fraction..		.....	5	
Ketene.....	463-51-4	0.5	0.9	
Lead inorganic (as Pb); see 1910.1025.....	7439-92-1			
Limestone.....	1317-65-3			
Total dust.....		.....	15	
Respirable fraction..		.....	5	
Lindane.....	58-89-9	.....	0.5	X
Lithium hydride.....	7580-67-8	.....	0.025	
L.P.G. (Liquified petroleum gas).....	68476-85-7	1000	1800	
Magnesite.....	546-93-0			
Total dust.....		.....	15	
Respirable fraction..		.....	5	
Magnesium oxide fume...	1309-48-4			
Total Particulate....		.....	15	
Malathion.....	121-75-5			
Total dust.....		.....	15	X
Maleic anhydride.....	108-31-6	0.25	1	
Manganese compounds (as Mn).....	7439-96-5	.....	(C)5	
Manganese fume (as Mn).	7439-96-5	.....	(C)5	
Marble.....	1317-65-3			
Total dust.....		.....	15	
Respirable fraction..		.....	5	
Mercury (aryl and inorganic)(as Hg)....	7439-97-6		(2)	
Mercury (organo) alkyl compounds (as Hg)....	7439-97-6		(2)	
Mercury (vapor) (as Hg)	7439-97-6		(2)	
Mesityl oxide.....	141-79-7	25	100	
Methanethiol; see Methyl mercaptan.				

Methoxychlor.....	72-43-5			
Total dust.....		.....	15	
2-Methoxyethanol; (Methyl cellosolve)..	109-86-4	25	80	X
2-Methoxyethyl acetate (Methyl cellosolve acetate).....	110-49-6	25	120	X
Methyl acetate.....	79-20-9	200	610	
Methyl acetylene (Propyne).....	74-99-7	1000	1650	
Methyl acetylene propadiene mixture (MAPP).....		1000	1800	
Methyl acrylate.....	96-33-3	10	35	X
Methylal (Dimethoxy-methane)..	109-87-5	1000	3100	
Methyl alcohol.....	67-56-1	200	260	
Methylamine.....	74-89-5	10	12	
Methyl amyl alcohol; see Methyl Isobutyl carbinol.....				
Methyl n-amyl ketone...	110-43-0	100	465	
Methyl bromide.....	74-83-9	(C)20	(C)80	X
Methyl butyl ketone; see 2-Hexanone.....				
Methyl cellosolve; see 2-Methoxyethanol.				
Methyl cellosolve acetate; see 2-Methoxyethyl acetate.....				
Methyl chloride.....	74-87-3		(2)	
Methyl chloroform (1,1,1-Trichloro-ethane).....	71-55-6	350	1900	
Methylcyclohexane.....	108-87-2	500	2000	
Methylcyclohexanol.....	25639-42-3	100	470	
o-Methylcyclohexanone..	583-60-8	100	460	X
Methylene chloride.....	75-09-2		(2)	
Methyl ethyl ketone (MEK); see 2-Butanone				
Methyl formate.....	107-31-3	100	250	
Methyl hydrazine (Monomethyl hydrazine).....	60-34-4	(C)0.2	(C)0.35	X
Methyl iodide.....	74-88-4	5	28	X
Methyl isoamyl ketone..	110-12-3	100	475	
Methyl isobutyl carbinol.....	108-11-2	25	100	X
Methyl isobutyl ketone; see Hexone.....				
Methyl isocyanate.....	624-83-9	0.02	0.05	X
Methyl mercaptan.....	74-93-1	(C)10	(C)20	
Methyl methacrylate....	80-62-6	100	410	
Methyl propyl ketone; see 2-Pentanone.....				
alpha-Methyl styrene...	98-83-9	(C)100	(C)480	
Methylene bisphenyl isocyanate (MDI).....	101-68-8	(C)0.02	(C)0.2	
Mica; see Silicates....				
Molybdenum (as Mo).....	7439-98-7			
Soluble compounds....		.....	5	
Insoluble Compounds Total dust.....		.....	15	
Monomethyl aniline.....	100-61-8	2	9	X
Monomethyl hydrazine; see Methyl hydrazine.				
Morpholine.....	110-91-8	20	70	X
Naphtha (Coal tar).....	8030-30-6	100	400	
Naphthalene.....	91-20-3	10	50	
alpha-Naphthylamine;				

see 1910.1004.....	134-32-7			
beta-Naphthylamine; see 1910.1009.....	91-59-8			
Nickel carbonyl (as Ni)	13463-39-3	0.001	0.007	
Nickel, metal and insoluble compounds (as Ni).....	7440-02-0	.....	1	
Nickel, soluble compounds (as Ni)....	7440-02-0	.....	1	
Nicotine.....	54-11-5	.....	0.5	X
Nitric acid.....	7697-37-2	2	5	
Nitric oxide.....	10102-43-9	25	30	
p-Nitroaniline.....	100-01-6	1	6	X
Nitrobenzene.....	98-95-3	1	5	X
p-Nitrochlorobenzene...	100-00-5	.....	1	X
4-Nitrodiphenyl; see 1910.1003.....	92-93-3			
Nitroethane.....	79-24-3	100	310	
Nitrogen dioxide.....	10102-44-0	(C)5	(C)9	
Nitrogen trifluoride...	7783-54-2	10	29	
Nitroglycerin.....	55-63-0	(C)0.2	(C)2	X
Nitromethane.....	75-52-5	100	250	
1-Nitropropane.....	108-03-2	25	90	
2-Nitropropane.....	79-46-9	25	90	
N-Nitrosodimethylamine; see 1910.1016				
Nitrotoluene (all isomers).....		5	30	X
o-isomer.....	88-72-2			
m-isomer.....	99-08-1			
p-isomer.....	99-99-0			
Nitrotrichloromethane; see Chloropicrin.....				
Octachloronaphthalene..	2234-13-1	.....	0.1	X
Octane.....	111-65-9	500	2350	
Oil mist, mineral.....	8012-95-1	.....	5	
Osmium tetroxide (as Os).....	20816-12-0	.....	0.002	
Oxalic acid.....	144-62-7	.....	1	
Oxygen difluoride.....	7783-41-7	0.05	0.1	
Ozone.....	10028-15-6	0.1	0.2	
Paraquat, respirable dust.....	4685-14-7 1910-42-5 2074-50-2	.....	0.5	X
Parathion.....	56-38-2	.....	0.1	X
Particulates not otherwise regulated (PNOR)(f).....				
Total dust.....		.....	15	
Respirable fraction..		.....	5	
PCB; see Chlorodiphenyl (42% and 54% chlorine).....				
Pentaborane.....	19624-22-7	0.005	0.01	
Pentachloronaphthalene.	1321-64-8	.....	0.5	X
Pentachlorophenol.....	87-86-5	.....	0.5	X
Pentaerythritol.....	115-77-5			
Total dust.....		.....	15	
Respirable fraction..		.....	5	
Pentane.....	109-66-0	1000	2950	
2-Pentanone (Methyl propyl ketone).....	107-87-9	200	700	
Perchloroethylene (Tetrachloroethylene)	127-18-4		(2)	
Perchloromethyl mercaptan.....	594-42-3	0.1	0.8	
Perchloryl fluoride....	7616-94-6	3	13.5	
Petroleum distillates (Naphtha)(Rubber Solvent).....		500	2000	

Phenol	108-95-2	5	19	X
p-Phenylene diamine	106-50-3	.....	0.1	X
Phenyl ether, vapor	101-84-8	1	7	
Phenyl ether-biphenyl mixture, vapor		1	7	
Phenylethylene; see Styrene				
Phenyl glycidyl ether (PGE)	122-60-1	10	60	
Phenylhydrazine	100-63-0	5	22	X
Phosdrin (Mevinphos)	7786-34-7	.....	0.1	X
Phosgene (Carbonyl chloride)	75-44-5	0.1	0.4	
Phosphine	7803-51-2	0.3	0.4	
Phosphoric acid	7664-38-2	.....	1	
Phosphorus (yellow)	7723-14-0	.....	0.1	
Phosphorus pentachloride	10026-13-8	.....	1	
Phosphorus pentasulfide	1314-80-3	.....	1	
Phosphorus trichloride	7719-12-2	0.5	3	
Phthalic anhydride	85-44-9	2	12	
Picloram	1918-02-1			
Total dust		.....	15	
Respirable fraction		.....	5	
Picric acid	88-89-1	.....	0.1	X
Pindone (2-Pivalyl-1, 3-indandione)	83-26-1	.....	0.1	
Plaster of paris	26499-65-0			
Total dust		.....	15	
Respirable fraction		.....	5	
Platinum (as Pt)	7440-06-4			
Metal		.....	.....	
Soluble Salts		.....	0.002	
Portland cement	65997-15-1			
Total dust		.....	15	
Respirable fraction		.....	5	
Propane	74-98-6	1000	1800	
beta-Propriolactone; see 1910.1013	57-57-8			
n-Propyl acetate	109-60-4	200	840	
n-Propyl alcohol	71-23-8	200	500	
n-Propyl nitrate	627-13-4	25	110	
Propylene dichloride	78-87-5	75	350	
Propylene imine	75-55-8	2	5	X
Propylene oxide	75-56-9	100	240	
Propyne; see Methyl acetylene				
Pyrethrum	8003-34-7	.....	5	
Pyridine	110-86-1	5	15	
Quinone	106-51-4	0.1	0.4	
RDX: see Cyclonite				
Rhodium (as Rh), metal fume and insoluble compounds	7440-16-6	.....	0.1	
Rhodium (as Rh), soluble compounds	7440-16-6	.....	0.001	
Ronnel	299-84-3	.....	15	
Rotenone	83-79-4	.....	5	
Rouge				
Total dust		.....	15	
Respirable fraction		.....	5	
Selenium compounds (as Se)	7782-49-2	.....	0.2	
Selenium hexafluoride (as Se)	7783-79-1	0.05	0.4	
Silica, amorphous, precipitated and gel	112926-00-8		(3)	
Silica, amorphous, diatomaceous earth, containing less than 1% crystalline silica	61790-53-2		(3)	

Silica, crystalline cristobalite, respirable dust.....	14464-46-1		(3)	
Silica, crystalline quartz, respirable dust.....	14808-60-7		(3)	
Silica, crystalline tripoli (as quartz), respirable dust.....	1317-95-9		(3)	
Silica, crystalline tridymite, respirable dust.....	15468-32-3		(3)	
Silica, fused, respirable dust.....	60676-86-0		(3)	
Silicates (less than 1% crystalline silica) Mica (respirable dust).....	12001-26-2		(3)	
Soapstone, total dust	.....		(3)	
Soapstone, respirable dust.....	.....		(3)	
Talc (containing asbestos): use asbestos limit: see 29 CFR 1910.1001.....			(3)	
Talc (containing no asbestos), respirable dust.....	14807-96-6		(3)	
Tremolite, asbestiform; see 1910.1001.....				
Silicon.....	7440-21-3			
Total dust.....		.....	15	
Respirable fraction..		.....	5	
Silicon carbide.....	409-21-2			
Total dust.....		.....	15	
Respirable fraction..		.....	5	
Silver, metal and soluble compounds (as Ag).....	7440-22-4	.....	0.01	
Soapstone; see Silicates.....				
Sodium fluoroacetate...	62-74-8	.....	0.05	X
Sodium hydroxide.....	1310-73-2	.....	2	
Starch.....	9005-25-8			
Total dust.....		.....	15	
Respirable fraction..		.....	5	
Stibine.....	7803-52-3	0.1	0.5	
Stoddard solvent.....	8052-41-3	500	2900	
Strychnine.....	57-24-9	.....	0.15	
Styrene.....	100-42-5		(2)	
Sucrose.....	57-50-1			
Total dust.....		.....	15	
Respirable fraction..		.....	5	
Sulfur dioxide.....	7446-09-5	5	13	
Sulfur hexafluoride....	2551-62-4	1000	6000	
Sulfuric acid.....	7664-93-9	.....	1	
Sulfur monochloride....	10025-67-9	1	6	
Sulfur pentafluoride...	5714-22-7	0.025	0.25	
Sulfuryl fluoride.....	2699-79-8	5	20	
Systox; see Demeton...				
2,4,5-T (2,4,5-tri-chlorophenoxyacetic acid).....	93-76-5	.....	10	
Talc; see Silicates...				
Tantalum, metal and oxide dust.....	7440-25-7	.....	5	
TEDP (Sulfotep).....	3689-24-5	.....	0.2	X
Tellurium and compounds (as Te)....	13494-80-9	.....	0.1	
Tellurium hexafluoride				

(as Te).....	7783-80-4	0.02	0.2	
Temephos.....	3383-96-8			
Total dust.....		.....	15	
Respirable fraction..		.....	5	
TEPP (Tetraethyl pyrophosphaate).....	107-49-3	.....	0.05	X
Terphenylis.....	26140-60-3	(C)1	(C)9	
1,1,1,2-Tetrachloro-2, 2-difluoroethane.....	76-11-9	500	4170	
1,1,2,2-Tetrachloro-1, 2-difluoroethane.....	76-12-0	500	4170	
1,1,2,2-Tetrachloro-ethane.....	79-34-5	5	35	X
Tetrachoroethylene; see Perchloroethylene				
Tetrachloromethane; see Carbon tetrachloride.				
Tetrachloronaphthalene.	1335-88-2	.....	2	X
Tetraethyl lead (as Pb)	78-00-2	.....	0.075	X
Tetrahydrofuran.....	109-99-9	200	590	
Tetramethyl lead, (as Pb).....	75-74-1	.....	0.075	X
Tetramethyl succinonitrile.....	3333-52-6	0.5	3	X
Tetranitromethane.....	509-14-8	1	8	
Tetryl (2,4,6-Trinitro-phenylmethyl-nitramine).....	479-45-8	.....	1.5	X
Thallium, soluble compounds (as Tl)....	7440-28-0	.....	0.1	X
4,4'-Thiobis(6-tert, Butyl-m-cresol).....	96-69-5			
Total dust.....		.....	15	
Respirable fraction..		.....	5	
Thiram.....	137-26-8	.....	5	
Tin, inorganic compounds (except oxides) (as Sn).....	7440-31-5	.....	2	
Tin, organic compounds (as Sn).....	7440-31-5	.....	0.1	
Titanium dioxide.....	13463-67-7			
Total dust.....		.....	15	
Toluene.....	108-88-3		(2)	
Toluene-2, 4-diisocyanate (TDI).	584-84-9	(C)0.02	(C)0.14	
o-Toluidine.....	95-53-4	5	22	X
Toxaphene; see Chlorinated camphene.				
Tremolite; see Silicates.....				
Tributyl phosphate.....	126-73-8	.....	5	
1,1,1-Trichloroethane; see Methyl chloroform				
1,1,2-Trichloroethane..	79-00-5	10	45	X
Trichloroethylene.....	79-01-6		(2)	
Trichloromethane; see Chloroform				
Trichloronaphthalene...	1321-65-9	.....	5	X
1,2,3-Trichloropropane.	96-18-4	50	300	
1,1,2-Trichloro-1,2, 2-trifluoroethane....	76-13-1	1000	7600	
Triethylamine.....	121-44-8	25	100	
Trifluorobromomethane..	75-63-8	1000	6100	
2,4,6-Trinitrophenol; see Picric acid.....				
2,4,6-Trinitrophenyl-methyl nitramine; see Tetryl.....				
2,4,6-Trinitrotoluene (TNT).....	118-96-7	.....	1.5	X
Triorthocresyl				

phosphate	78-30-8	.....	0.1	
Triphenyl phosphate	115-86-6	.....	3	
Turpentine	8006-64-2	100	560	
Uranium (as U)	7440-61-1			
Soluble compounds		.....	0.05	
Insoluble compounds		.....	0.25	
Vanadium	1314-62-1			
Respirable dust (as V_2O_5))		.....	(C)0.5	
Fume (as V_2O_5)		.....	(C)0.1	
Vegetable oil mist				
Total dust		.....	15	
Respirable fraction		.....	5	
Vinyl benzene; see Styrene				
Vinyl chloride; see 1910.1017	75-01-4			
Vinyl cyanide; see Acrylonitrile				
Vinyl toluene	25013-15-4	100	480	
Warfarin	81-81-2	.....	0.1	
Xylenes (o-, m-, p-isomers)	1330-20-7	100	435	
Xylidine	1300-73-8	5	25	X
Yttrium	7440-65-5	.....	1	
Zinc chloride fume	7646-85-7	.....	1	
Zinc oxide fume	1314-13-2	.....	5	
Zinc oxide	1314-13-2			
Total dust		.....	15	
Respirable fraction		.....	5	
Zinc stearate	557-05-1			
Total dust		.....	15	
Respirable fraction		.....	5	
Zirconium compounds (as Zr)	7440-67-7	.....	5	

Footnote(1) The PELs are 8-hour TWAs unless otherwise noted; a (C) designation denotes a ceiling limit. They are to be determined from breathing-zone air samples.

Footnote(a) Parts of vapor or gas per million parts of contaminated air by volume at 25 degrees C and 760 torr.

Footnote(b) Milligrams of substance per cubic meter of air. When entry is in this column only, the value is exact; when listed with a ppm entry, it is approximate.

Footnote(c) The CAS number is for information only. Enforcement is based on the substance name. For an entry covering more than one metal compound measured as the metal, the CAS number for the metal is given - not CAS numbers for the individual compounds.

Footnote(d) The final benzene standard in 1910.1028 applies to all occupational exposures to benzene except in some circumstances the distribution and sale of fuels, sealed containers and pipelines, coke production, oil and gas drilling and production, natural gas processing, and the percentage exclusion for liquid mixtures; for the excepted subsegments, the benzene limits in Table Z-2 apply. See 1910.1028 for specific circumstances.

Footnote(e) This 8-hour TWA applies to respirable dust as measured by a vertical elutriator cotton dust sampler or equivalent instrument. The time-weighted average applies to the cotton waste processing operations of waste recycling (sorting, blending, cleaning and willowing) and garnetting. See also 1910.1043 for cotton dust limits applicable to other sectors.

Footnote(f) All inert or nuisance dusts, whether mineral, inorganic, or organic, not listed specifically by substance name are covered by the Particulates Not Otherwise Regulated (PNOR) limit which is the same as the inert or nuisance dust limit of Table Z-3.

Footnote(2) See Table Z-2.

Footnote(3) See Table Z-3

Footnote(4) Varies with compound.

Footnote(5) See Table Z-2 for the exposure limits for any operations or sectors where the exposure limits in 1910.1026 are stayed or are otherwise not in effect.

TABLE Z-2

Substance	8-hour time weighted average	Acceptable ceiling concentration	Acceptable maximum peak above the acceptable ceiling concentration for an 8-hr shift	
			Concentration	Maximum duration
Benzene[a] (Z37.40-1969)	10 ppm	25 ppm	50 ppm	10 minutes.
Beryllium and beryllium compounds (Z37.29-1970)	2 ug/m(3)	5 ug/m(3)	25 ug/m(3)	30 minutes.
Cadmium fume[b] (Z37.5-1970)	0.1 mg/m(3)	0.3 mg/m(3)	.....	
Cadmium dust[b] (Z37.5-1970)	0.2 mg/m(3)	0.6 mg/m(3)		
Carbon disulfide (Z37.3-1968)	20 ppm	30 ppm	100 ppm	30 minutes.
Carbon tetrachloride (Z37.17-1967)	10 ppm	25 ppm	200 ppm	5 min. in any 3 hrs.
Chromic acid and chromates (Z37-7-1971)[c]	.....	1 mg/10 m(3)		
Ethylene dibromide (Z37.31-1970)	20 ppm	30 ppm	50 ppm	5 minutes.
Ethylene dichloride (Z37.21-1969)	50 ppm	100 ppm	200 ppm	5 min. in any 3 hrs.
Fluoride as dust (Z37.28-1969)	2.5 mg/m(3)	.....	.....	
Formaldehyde: see 1910.1048	.....	.....	.....	
Hydrogen fluoride (Z37.28-1969)	3 ppm	.....	.....	
Hydrogen sulfide (Z37.2-1966)	.....	20 ppm	50 ppm	10 mins. once only if no other meas. exp. occurs.
Mercury (Z37.8-1971)	.....	1 mg/10m(3)	.....	
Methyl chloride (Z37.18-1969)	100 ppm	200 ppm	300 ppm	5 mins. in any 3 hrs.
Methylene Chloride: see 1910.1052				
Organo (alkyl) mercury (Z37.30-1969)	0.01mg/m(3)	0.04 mg/m(3)	.....	
Styrene (Z37.15-1969)	100 ppm	200 ppm	600 ppm	5 mins. in any 3 hrs.
Tetrachloroethylene	100 ppm	200 ppm	300 ppm	5 mins. in any 3 hrs.
Toluene (Z37.12-1967)	200 ppm	300 ppm	500 ppm	10 minutes
Trichloroethylene (Z37.19-1967)	100 ppm	200 ppm	300 ppm	5 mins. in any 2 hrs.

Footnote[(a)] This standard applies to the industry segments exempt from the 1 ppm 8-hour TWA and 5 ppm STEL of the benzene standard at 1910.1028.

Footnote[(b)] This standard applies to any operations or sectors for which the Cadmium standard, 1910.1027, is stayed or otherwise not in effect.

Footnote[(c)] Footnote(c) This standard applies to any operations or sectors for which the exposures limit in the Chromium (VI) standard, Sec. 1910.1026, is stayed or is otherwise not in effect. [62 FR 42018, August 4, 1997] as amended [71 FR 36009, June 23, 2006]

TABLE Z-3 Mineral Dusts

Substance	mppcf [a]	mg/m^3
Silica: Crystalline		
Quartz (Respirable)	$\frac{250}{\%SiO_2+5}$ [b]	$\frac{10\ mg/m^3}{\%SiO_2+2}$ [e]
Quartz (Total Dust)	. . . . .	$\frac{30\ mg/m^3}{\%SiO_2+2}$
▪ Cristobalite: Use ½ the value calculated from the count or mass formulae for quartz. ▪ Tridymite: Use ½ the value calculated from the formulae for quartz.		
Amorphous, including natural diatomaceous earth	20	$\frac{80\ mg/m^3}{\%SiO_2}$
Silicates (less than 1% crystalline silica):		
Mica	20	
Soapstone	20	
Talc (not containing asbestos)	20[c]	
Talc (containing asbestos) Use asbestos limit		
Tremolite, asbestiform (see 29 CFR 1910.1001)		
Portland cement . . .	50	
Graphite (Natural)	15	
Coal Dust:		
Respirable fraction less than 5% SiO_2	. . . . .	2.4 mg/m^3 [e]
Respirable fraction greater than 5% SiO_2	. . . . .	$\frac{10\ mg/m^3}{\%SiO_2+2}$ [e]
Inert or Nuisance Dust:[d]		
Respirable fraction	15	5 mg/m^3
Total dust	50	15 mg/m^3

Note -- Conversion factors - mppcf X 35.3 = million particles per cubic meter = particles per c.c.

[a] Millions of particles per cubic foot of air, based on impinger samples counted by light-field techniques.

[b] The percentage of crystalline silica in the formula is the amount determined from airborne samples, except in those instances in which other methods have been shown to be applicable.

[c] Containing less than 1% quartz; if 1% quartz or more, use quartz limit.

[d] All inert or nuisance dusts, whether mineral, inorganic, or organic, not listed specifically by substance name are covered by this limit, which is the same as the Particulates Not Otherwise Regulated (PNOR) limit in Table Z-1.

[e] Both concentration and percent quartz for the application of this limit are to be determined from the fraction passing a size-selector with the following characteristics:

Aerodynamic diameter (unit density sphere)	Percent passing selector
2	90
2.5	75
3.5	50
5.0	25
10	0

The measurements under this note refer to the use of an AEC (now NRC) instrument. The respirable fraction of coal dust is determined with an MRE; the figure corresponding to that of 2.4 mg/m^3 in the table for coal dust is 4.5 mg/m^3.

[Note: This document was changed to an html version as of 11/24/2004]

[58 FR 35340, June 30, 1993; 58 FR 40191, July 27, 1993, as amended at 61 FR 56831, Nov. 4, 1996; 62 FR 1600, Jan. 10, 1997; 62 FR 42018, Aug. 4,1997]

APPENDIX C: CHEMICALS THAT ARE TOXIC BY SKIN CONTACT

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Chemicals That Are Toxic By Skin Contact

The following chemicals have been identified by the Occupational Safety and Health Administration (OSHA) and/or the American Conference of Governmental Industrial Hygienists (ACGIH) as chemicals that require skin protection or the use of other methods to prevent or reduce skin exposure. These chemicals present a significant degree of toxicity by skin contact. **Many chemicals not listed here also require the use of gloves** because of other hazardous characteristics.

Always refer to the glove manufacturers glove selection guides when choosing gloves for use with any chemical. Chemicals that are not listed may not have been tested. Some chemicals may not have an acceptable glove material based on the permeation and degradation tests. In this case, engineering controls, work practice controls or other methods must be used to prevent or reduce skin exposure to these chemicals.

Manufacturer's glove selection guides are available directly from the manufacturer's websites or by reading the relevant MSDS.

Chemical	CAS Number	Reference	
		OSHA[4]	ACGIH[5]
Acetone cyanohydrin	75-86-5		x
Acetonitrile	75-05-8		x
Acrolein	107-02-8		x
Acrylamide	79-06-1	x	x
Acrylic acid	79-10-7		x
Acrylonitrile	107-13-1		x
Adiponitrile	111-69-3		x
Aldrin	309-00-2	x	x
Allyl alcohol	107-18-6	x	x
4-Aminodiphenyl	92-67-1		x
Ammonium perfluorooctanoate	3825-26-1		x
Aniline	62-53-3	x	x
(*o*- & *p*-) Anisidine	90-04-0/104-94-9	x	x
Azinphos-methyl	86-50-0	x	x
Benzene	71-43-2		x
Benzidine	92-87-5		x
Benzotrichloride	98-07-7		x
Bromoform	75-25-2	x	x
2-Butoxyethanol (EGBE)	111-76-2	x	
n- Butylamine	109-73-9	x	x
tert-Butyl chromate (as CrO_3)	1189-85-1	x	x
o-sec-Butylphenol	89-72-5		x
Captafol	2425-06-1		x
Carbon disulfide	75-15-0		x
Carbon tetrachloride	56-23-5		x
Catechol	120-80-9		x
Chlordane	57-74-9	x	x
Chlorinated camphene	8001-35-2	x	x
Chloroacetone	78-95-5		x
Chloroacetyl chloride	79-04-9		x
o-Chlorobenzylidene malononitrile	2698-41-1		x
Chlorodiphenyl	53469-21-9/11097-69-1		x
β-Chloroprene	126-99-8	x	
1-Chloro-2-propanol	127-00-4		x
2-Chloro-1-propanol	78-89-7		x
2-Chloropropionic acid	598-78-7		x
Chloropyrifos	2921-88-2		x
o, m, & p Cresol	1319-77-3; 95-48-7;108-39-4; 106-44-5	x	x
Crotonaldehyde	4170-30-3		x
Cumene	98-82-8	x	
Cyanide salts	592-01-8; 151-50-8; 143-33-9		x
Cyclohexanol	108-93-0		x

Chemical	CAS Number	Reference	
		OSHA[4]	ACGIH[5]
Cyclohexanone	108-94-1		x
Cyclonite	121-82-4		x
Decaborane	11702-41-9	x	x
Demeton	8065-48-3		x
Demeton-S-methyl (Systox)	919-86-8	x	x
Diazinon	333-41-5		x
2-*N*-Dibutylaminoethanol	102-81-8		x
Dibutyl phenyl phosphate	2528-36-1		x
3,3'-Dichlorobenzidine	91-94-1		x
1,4-Dichloro-2-butene	764-41-0		x
Dichlorodiphenyltri-chloroethane (DDT)	50-29-3	x	
Dichloroethyl ether	111-44-4	x	x
1,3-Dichloropropene	542-75-6		x
Dichlorvos (DDVP)	62-73-7	x	x
Dicrotophos	141-66-2		x
Dieldrin	60-57-1	x	x
Diesel fuel	68334-30-5; 68476-30-2; 68476-31-3; 68476-34-6; 77650-28-3		x
Diethanolamine	111-42-2		x
Diethylamine	109-89-7		x
2-Diethylaminoethanol	100-37-8	x	x
Diethylene triamine	111-40-0		x
Diisopropylamine	108-18-9	x	x
Dimethyl acetamide	127-19-5	x	x
bis (2-Dimethylaminoethyl) ether	3033-62-3		x
Dimethylaniline	121-69-7	x	x
Dimethylformamide	68-12-2	x	x
1,1-Dimethylhydrazine	57-14-7	x	x
Dimethyl sulfate	77-78-1	x	x
(*o*-,*m*-, & *p*-) Dinitrobenzene	528-29-0; 99-65-0; 100-25-4	x	x
Dinitro-o-cresol	534-52-1	x	x
Dinitrotoluene	25321-14-6	x	x
1,4-Dioxane	123-91-1	x	x
Dioxathion	78-34-2		x
Dipropylene glycol methyl ether	34590-94-8	x	
Diquat	2764-72-9		x
Disulfoton	298-04-4		x
Endosulfan	115-29-7	x	x
Endrin	72-20-8	x	x
Epichlorohydrin	106-89-8	x	x
EPN	2104-64-5	x	x
Ethion	563-12-2		x
2-Ethoxyethanol (Cellosolve)	110-80-5	x	x
2-Ethoxyethyl acetate (Cellosolve acetate)	111-15-9	x	x
Ethyl acrylate	140-88-5	x	
Ethylamine	75-04-7		x
Ethyl bromide	74-96-4		x
Ethyl chloride	75-00-3		x
Ethylene chlorohydrin	107-07-3	x	x
Ethylenediamine	107-15-3		x
Ethylene dibromide	106-93-4		x
Ethylene glycol dinitrate	628-96-6	x	x
Ethylenimine	151-56-4		x
N-Ethylmorpholine	100-74-3	x	x
Fenamiphos	22224-92-6		x
Fenthion	55-38-9		x
Fonofos	944-22-9		x
Formaldehyde	50-00-0	x	
Formamide	75-12-7		x
Furfural	98-01-1	x	x
Furfuryl alcohol	98-00-0		x
Heptachlor & heptachlor epoxide	76-44-8; 1024-57-3	x	x
Hexachlorobenzene	118-74-1		x
Hexachlorobutadiene	87-68-3		x

Chemical	CAS Number	Reference	
		OSHA[4]	ACGIH[5]
Hexachloroethane	67-72-1	x	x
Hexachloronaphthalene	1335-87-1	x	x
Hexafluoroacetone	684-16-2		x
Hexamethylphosphoramide	680-31-9		x
n-Hexane	110-54-3		x
Hydrazine	302-01-2		x
Hydrogen cyanide	74-90-8	x	x
2-Hydroxypropyl acrylate	999-61-1		x
Isooctyl alcohol	26952-21-6		x
2-Isopropoxyethanol	109-59-1		x
N-Isopropylaniline	768-52-5		x
Latex, natural rubber latex as total proteins	9006-04-6		x
Lindane	58-89-9	x	x
Malathion	121-75-5	x	x
Manganese cyclopentadienyl tricarbonyl	12079-65-1		x
Mercury (Inorganic)	7439-97-6		x
Mercury (Organic):	7439-97-6		x
Methanol	67-56-1		x
2-Methoxyethanol; (Methyl cellosolve)	109-86-4	x	x
2-Methoxyethyl acetate (Methyl cellosolve acetate)	110-49-6	x	x
bis-(2-Methoxypropyl) ether (DPGME)	34590-94-8		x
Methyl acrylate	96-33-3	x	x
Methylacrylonitrile	126-98-7		x
N-Methyl aniline	100-61-8		x
Methyl bromide	74-83-9	x	x
Methyl n-butyl ketone	591-78-6		x
Methyl chloride	74-87-3		x
o-Methylcyclohexanone	583-60-8	x	x
2-Methylcyclopentadienyl manganese tricarbonyl	12108-13-3		x
Methyl demeton	8022-00-2		x
4,4'-Methylene bis(2-chloroaniline)	101-14-4		x
4-4'-Methylene dianiline	1071-77-9		x
Methyl hydrazine	60-34-4	x	x
Methyl iodide	74-88-4	x	x
Methyl isobutyl carbinol	108-11-2	x	x
Methyl isocyanate	624-83-9	x	x
Methyl parathion	298-00-0		x
Methyl vinyl ketone	78-94-4		x
Mevinphos (Phosdrin)	7786-34-7		x
Monocrotophos	6923-22-4		x
Monomethyl aniline	100-61-8	x	
Morpholine	110-91-8	x	x
Naled	300-76-5		x
Naphthalene	91-20-3		x
Nicotine	54-11-5	x	x
p-Nitroaniline	100-01-6	x	x
Nitrobenzene	98-95-3	x	x
p-Nitrochlorobenzene	100-00-5	x	x
4-Nitrodiphenyl	92-93-3		x
Nitroglycerin	55-63-0	x	x
N-Nitrosodimethylamine	62-75-9		x
(*o*-,*m*-, & *p*-) Nitrotoluene	88-72-2; 99-08-1; 99-99-0	x	x
Octachloronaphthalene	2234-13-1	x	x
Paraquat	4685-14-7	x	
Parathion	56-38-2	x	x
Pentachloronaphthalene	1321-64-8	x	x
Pentachlorophenol	87-86-5	x	x
Phenol	108-95-2	x	x
Phenothiazine	92-84-2		x
Phenyl glycidyl ether	122-60-1		x
p-Phenylene diamine	106-50-3	x	
Phenylhydrazine	100-63-0	x	x
Phenyl mercaptan	108-98-5		x
Phorate	298-02-2		x

Chemical	CAS Number	Reference	
		OSHA[4]	ACGIH[5]
Phosdrin (Mevinphos)	7786-34-7	x	
Picric acid (2,4,6-trinitrophenol)	88-89-1	x	
n-Propanol (*n*- propyl alcohol)	71-23-8		x
Propargyl alcohol	107-19-7		x
Propylene glycol dinitrate	6423-43-4		x
Propylenimine	75-55-8	x	x
Sodium azide	26628-22-8		
Sodium fluoroacetate	62-74-8	x	x
Sulfotep (TEDP)	3689-24-5	x	x
Terbufos	13071-79-9		x
1,1,2,2-Tetrachloroethane	79-34-5	x	x
Tetrachloronaphthalene	1335-88-2	x	
Tetraethyl lead	78-00-2	x	x
Tetraethyl pyrophosphate (TEPP)	107-49-3	x	x
Tetramethyl lead	75-74-1	x	x
Tetramethyl succinonitrile	3333-52-6	x	x
Tetryl (2,4,6-Trinitrophenylmethylnitramine)	479-45-8	x	
Thallium	7440-28-0	x	x
Thioglycolic acid	68-11-1		x
Tin (organic compounds)	7440-31-5		x
o-Tolidine	119-93-7	x	x
Toluene	108-88-3		x
(*o*-,*m*-, & *p*-) Toluidine	95-53-4; 108-44-1; 106-49-0		x
1,1,2-Trichloroethane	79-00-5	x	x
Trichloronaphthalene	1321-65-9	x	x
1,2,3 Trichloropropane	96-18-4		x
Triethylamine	121-44-8		x
2,4,6-Trinitrotoluene (TNT)	118-96-7	x	x
Triorthocresyl phosphate	78-30-8		x
Vinyl cyclohexene dioxide	106-87-6		x
m-Xylene α,α'-diamine	1477-55-0		x
Xylidine	1300-73-8	x	

APPENDIX D: PERSONAL PROTECTIVE EQUIPMENT HAZARD ASSESSMENT FORM

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Personal Protective Equipment
Hazard Assessment
for Laboratory Workers

The Occupational Safety and Health Administration (OSHA) requires a personal protective equipment hazard assessment for any tasks that require personal protective equipment (e.g., gloves, safety glasses). Please check all activities that apply to your area. If a task is not listed add a new task at the bottom with the associated hazards and personal protective equipment (PPE).

Date:

Supervisor/PI: _____ Assessment by:

Department: _____ Building/Room Number(s):

Chemical Hazards			
Check All That Apply	**Task**	**Potential Hazard**	**Recommended PPE**
☐	Working with small volumes of corrosive liquids (< 1 liter).	Skin or eye damage	Safety glasses or goggles Light chemically resistant gloves Lab coat, closed shoe, pants
☐	Working with large volumes of corrosive liquids (> 1 liter), acutely toxic corrosives, or work which creates a splash hazard	Large surface area skin or eye damage, poisoning, or great potential for eye and skin damage	Safety goggles and face shield Heavy chemically resistant gloves Lab coat, closed shoe, pants, and chemically resistant apron
☐	Working with small volumes of organic solvents (< 1 liter).	Skin or eye damage Slight poisoning potential through skin contact	Safety glasses or goggles Light chemically resistant gloves Lab coat, closed shoe, pants
☐	Working with large volumes of organic solvents (> 1 liter), very dangerous solvents, or work which creates a splash hazard	Major skin or eye damage, or potential poisoning through skin contact	Safety goggles and face shield Heavy chemically resistant gloves Lab coat, closed shoe, pants, and chemically resistant apron
☐	Working with toxic or hazardous chemicals (solid or liquid).	Potential skin or eye damage, potential poisoning through skin contact.	Safety glasses (goggles for large quantities), light chemically resistant gloves, lab coat, closed shoe, pants.
☐	Working with acutely toxic or hazardous chemicals (solid or liquid).	Great potential skin or eye damage, great potential poisoning through skin contact.	Safety goggles, appropriate heavy chemically resistant gloves, lab coat, closed shoe, pants Coveralls and booties if necessary.
☐	Working with explosives.	Skin or eye damage from flying projectiles or chemicals.	Blast shield, safety goggles or full face shield, chemically resistant gloves, lab coat, closed shoe, pants.
☐	Working with chemical dusts.	Skin or eye damage, respiratory damage.	Safety glasses or goggles, appropriate gloves, lab coat, closed shoes or boots if necessary, pants, Approved respiratory protection (call EHS).
☐	Chemical spill cleanup.	Skin or eye damage, respiratory damage.	Safety glasses or goggles, appropriate gloves, lab coat, closed shoes or boots if necessary, pants, respiratory protection (call EHS).
Radiological Hazards			
☐	Working with solid radioactive materials or waste.	Potential cell damage, potential spread of radioactive materials.	Safety glasses, gloves, lab coat, closed shoe, pants.
☐	Working with radioactive chemicals (corrosives, flammables, liquids, powders, etc.).	Potential cell damage or spread of contamination plus hazards for the appropriate chemical hazards above.	Safety glasses (or goggles for splash hazard), light chemically resistant gloves, lab coat, closed shoe, pants. Use PPE for applicable chemical hazards above.
☐	Working with ultraviolet radiation.	Conjunctivitis, corneal damage, erythema.	UV face shield and goggles, lab coat, closed shoe, pants.
☐	Working with Laser radiation.	Retinal eye damage, skin damage.	Appropriate shaded goggles with optical density based on individual beam parameters, lab coat, closed shoe, pants. No jewelry or reflective items allowed.

Check All That Apply	Task	Potential Hazard	Recommended PPE
☐	Working with infrared emitting equipment (e.g., glass blowing).	Cataracts, flash burns to cornea.	Appropriate shaded goggles, lab coat, closed shoe, pants.
☐	Working with radioactive human blood, body fluids, or blood borne pathogens (BBP).	Potential cell damage, potential spread of radioactive contaminants, or potential BBP exposure.	Safety glasses (goggles for splash hazard), light latex gloves, lab coat, closed shoe, pants.
Biological Hazards			
☐	Working with small volumes of human blood, body fluids, tissues, or blood borne pathogens.	Potential contraction of infectious disease, potential spread of infectious disease.	Safety glasses, light latex gloves, lab coat, closed shoe, pants.
☐	Working with large volumes of human blood, body fluids, tissues, or blood borne pathogens.	Increased potential for contraction of infectious disease or increased potential for spread of infectious disease.	Safety goggles with face shield, latex gloves, lab coat, closed shoe, pants. Coveralls and boot covers if necessary.
☐	Working with live or poisonous animals and plants.	Animal bites, stings, or infectious disease. Skin or eye damage from contact with animal or plant poisons.	Safety glasses or goggles, protective gloves, lab coat, closed shoe, pants.
☐	Working with animal specimens (preserved or unpreserved).	Potential exposure to infectious disease, animal toxins, or preservatives.	Safety glasses or goggles, protective gloves, lab coat, closed shoe, pants.
Physical Hazards			
☐	Working with cryogenic liquids.	Major skin, tissue, or eye damage.	Safety glasses or goggles for large volumes, heavy insulated gloves, lab coat, closed shoe, pants.
☐	Working with very cold equipment or dry ice.	Frostbite, hypothermia.	Safety glasses, insulated gloves and warm clothing, lab coat, closed shoe, pants.
☐	Working with hot liquids, equipment, open flames (autoclave, bunsen burner, water bath, oil bath).	Burns resulting in skin or eye damage.	Safety glasses or goggles for large volumes, insulated gloves, lab coat, closed shoe, pants.
☐	Metal arc or tungsten arc (TIG) welding.	Conjunctivitis, corneal damage, erythema, skin burns.	Appropriate shaded goggles and face shield, gloves, lab coat, closed shoe, pants.
☐	Instrument repair.	Eye damage from foreign objects.	Safety glasses, no loose clothing or jewelry.
☐	Metal or woodworking.	Eye damage from foreign objects, lacerations from burrs or splinters.	Safety glasses, gloves, no loose clothing or jewelry.
☐	Working in nuisance dusts.	Skin or eye damage, respiratory damage.	Safety goggles, appropriate gloves, lab coat, closed shoes or boots if necessary, pants, NIOSH approved dust mask or other respiratory protection (call EHS).
☐	Glassware washing.	Lacerations.	Heavy rubber gloves, lab coat, closed shoes, pants.
☐	Working with loud equipment, noises, sounds, or alarms, etc.	Potential ear damage and hearing loss.	Ear plugs or headphones as necessary.
New Tasks or Other Hazards			
Check All That Apply	**Task**	**Potential Hazard**	**Recommended PPE**
☐			

APPENDIX E: SELECT CARCINOGENS

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SELECT CARCINOGENS

The Occupational Safety and Health Administration (OSHA) defines a "select carcinogen" as a substance that meets one of the following criteria:

1. Is regulated by OSHA as a carcinogen;
   2. Is listed under the category "known to be a carcinogen" or "reasonably anticipated to be a carcinogen" in the Annual Report on Carcinogens published by the National Toxicology Program (NTP); or
   3. Is listed under Group 1 ("carcinogenic to humans") or under Group 2A ('probably carcinogenic to humans") or 2B ("possibly carcinogenic to humans") by the International Agency for Research on Cancer (IARC).

This list includes other potential carcinogens including processes with hazardous byproducts which are typically not present in laboratories at Indiana University but may be used or generated during experimental procedures.

SUBSTANCE	OSHA	IARC	NTP
A-α-C (2-amino-9*h*-pyrido [2,3-*b*] indole)		x	
Acetaldehyde		x	x
Acetamide		x	
2-Acetylaminofluorene	x		x
Acrylamide		x	x
Acrylonitrile	x	x	x
Actinolite	x		
Adriamycin		x	x
AF-2 [2-(2-furyl)-3-(5-nitro-2-furyl) acrylamide]		x	
Aflatoxins (naturally ocurring)		x	x
Aflotoxins M1		x	
2-Aminoanthraquinone			x
p-Aminoazobenzene		x	
o-Aminoazotoluene		x	x
4-Aminobiphenyl	x	x	x
1-Amino-2,4-dibromoanthraquinone			x
1-Amino-2-methylanthraquinone			x
2-Amino-3,4-dimethylimidazo[4,5-*f*]quinoline (MEIQ)			x
2-Amino-3,8-dimethylimidazo[4,5-*f*]quinoxaline (MEIQx)			x
2-Amino-5-(5-nitro-2-furyl)-1,3,4-thiadiazole		x	
2-Amino-3-methylimidazo [4,5-*f*]quinoline (IQ)			x
2-Amino-1-methyl-6-phenylimidazo[4,5-*b*]pyridine (PhIP)		x	x
Amitrole			x
Amsacrine		x	
Androgenic (anabolic) steroids		x	
o-Anisidine		x	
o-Anisidine hydrochloride			x
Antimony trioxide		x	
Aramite®		x	
Arisolochic acids (naturally occurring mixtures of)		x	x

SUBSTANCE	OSHA	IARC	NTP
Arsenic and inorganic arsenic compounds	x	x	x
Arsenobetaine and other organic arsenic compounds		x	
Asbestos (all forms)	x	x	x
Auramine		x	
Azacitidine		x	x
Azaserine		x	
Azathioprine		x	x
Aziridine (dimethyleneimine)		x	
Benzene	x	x	x
Benzidine, benzidine based dyes, and dyes metabolized to benzidine	x	x	x
Benzo[*a*]anthracene		x	x
Benzo[j]ancanthrylene		x	
Benzo[*b*]fluoranthene		x	x
Benzo[c]phenanthrene		x	
Benzo[*j*]fluoranthene		x	x
Benzo[*k*]fluoranthene		x	x
Benzofuran		x	
Benzo[*a*]pyrene		x	x
Benzotrichloride			x
Benzyl violet 4B		x	
Beryllium and certain beryllium compounds		x	x
Betel quid with and without tobacco		x	
N,*N*-Bis(2-cloroethyl)-2-naphthylamine (Chlornaphazine)		x	
Bischloroethyl nitrosourea		x	x
Bleomycins		x	
Bracken fern		x	
Bromodichloromethane		x	x
2,2-bis-(Bromoethyl)-1,3-propanediol		x	x
Busulfan		x	
1,3-Butadiene		x	x
1,4-Butanediol dimethyl-sulfonate (Myleran)		x	x
Butylated hydroxyanisole (BHA)		x	x
β-Butyrolactone		x	
Cadmium and certain cadmium compounds	x	x	x
Caffeic acid		x	
Captafol		x	x
Carbon black		x	
Carbon tetrachloride		x	x
Catechol		x	
Ceramic fibers (respirable size)		x	x
Chlorambucil		x	x
Chloramphenicol		x	x
Chlordane		x	
Chlordecone (Kepone)		x	
Chlorendic acid		x	x
Chlorinated paraffins (C_{12}, 60% Chlorine)			x
α-Chlorinated toluenes (benzyl chloride, benzalchloride, benzotrichloride)		x	x
Chlornaphazine		x	

SUBSTANCE	OSHA	IARC	NTP
p-Chloroaniline		x	
3-Chloro-4-(dichloromethyl)-5-hydroxy-2(5H)-furanone		x	
1-(2-Chloroethyl)-3-cyclohexyl-1-nitrosourea (CCNU)		x	x
2-Chloroethyl -3- (4 methylcyclohexyl)-1-nitrosourea (MECCNU)		x	x
bis-Chloroethyl nitrosourea			x
Chloroform		x	x
bis-Chloromethyl ether (Dimethyl-1,1'-dichloro ether)	x	x	x
Chloromethyl methyl ether (Methyl chloromethyl ether)	x		x
1-Chloro-2-methylpropene		x	
3-Chloro-2-methylpropene			x
Chlorophenoxy herbicides		x	
4-Chloro-*o*-phenylenediamine		x	x
Cloroprene		x	x
p-Chloro-o-toluidine and p-chloro-o-toluidine hydrochloride			x
Chlorothalonil		x	
Chlorozotocin		x	x
Chromium, metallic and chromium [VI] compounds		x	x
Chrysene		x	
CI Acid Red 114 (see 3,3 dimethylbenzidine)		x	x
CI Direct Black 38 (see benzidine)			x
CI Basic Red 9 monohydrochloride		x	
CI Direct Blue 6 (see benzidine)			x
CI Direct Blue 15 (see 3,3 dimethoxybenzidine)		x	x
CI Direct brown 95 (see benzidine)			x
Ciclosporin		x	
Cisplatin		x	x
Citrus red no. 2		x	
Coal tars and coal tar pitches		x	x
Cobalt and cobalt compounds		x	
Cobalt metal with tungsten carbide		x	x
Cobalt metal without tungsten carbide		x	
Cobalt sulfate			x
p-Cresidine		x	x
Cupferron			x
Cycasin		x	
Cyclopenta[cd]pyrene		x	
Cyclophosphamide		x	x
Cyclosporin (ciclosporin)			x
Dacarbazine		x	x
Danthron (chrysazin 1,8-dihydroxyanthraquinone)		x	x
Daunomycin		x	
N,N'-Diacetylbenzidine		x	
2,4-Diaminoanisole		x	
2,4-Diaminoanisole sulfate			x
4,4'-Diaminodiphenyl ether		x	
2,4-Diaminotoluene		x	x
Dibenz[*a*,*h*]acridine		x	x

SUBSTANCE	OSHA	IARC	NTP
Dibenz[*a,j*]acridine		x	x
Dibenz[*a,h*]anthracene		x	x
7*h*-Dibenzo[*c,g*]carbazole		x	x
Dibenzo[*a,e*]pryrene		x	x
Dibenzo[*a,h*]pyrene		x	x
Dibenzo[*a,i*]pyrene		x	x
Dibenzo[*a,l*]pyrene		x	x
Diazoaminobenzene (DAAB)			x
1,2-Dibromo-3-chloropropane	x	x	x
1,2-Dibromoethane (Ethylene dibromide)			x
2,3-Dibromo-1-propanol		x	x
tris (2,3-Dibromopropyl) phosphate			x
Dichloroacetic acid		x	
1,4-Dichlorobenzene			x
p-Dichlorobenzene	x	x	
3,3'-Dichlorobenzidine	x	x	x
3,3'-Dichlorobenzidine dihydrochloride			x
3,3'-Dichloro-4,4[1]-diaminodiphenyl ether		x	
Dichlorodiphenyltrichloroethane (DDT)		x	x
1,2-Dichloroethane (Ethylene dichloride)		x	x
Dichloromethane (Methylene chloride)	x	x	x
1,3-Dichloropropene		x	x
Dichlorvos		x	
Diepoxybutane			x
Diesel fuel, marine		x	
Di(2-Ethylhexyl)phthalate		x	x
1,2 Diethylhydrazine		x	
Diethylstilbestrol		x	x
Diethyl sulfate		x	x
Diisopropyl sulfate		x	
Diglycidyl resorcinol ether		x	x
Dihydrosafrole		x	
3,3'-Dimethoxybenzidine (*o*-dianisidine) & dyes metabolized to 3,3 dimethoxybenzidine		x	x
3,3'-Dimethylbenzidine (*o*-tolidine) & dyes metabilized to 3,3'-dimethylbenzidine		x	x
4-Dimethylaminoazobenzene	x		x
p-Dimethylaminoazobenzene		x	
trans-2-[(Dimethylamino)methylamino] -5-2-(5-nitro-2-furyl)-vinyl]-1,3,4-oxidiazole		x	
2,6-Dimethylaniline (2,6-Xylidine)		x	
Dimethylarsenic acid		x	
Dimethylcarbamoyl chloride		x	x
1,1-Dimethylhydrazine		x	x
1,2-Dimethylhydrazine		x	
Dimethyl sulfate		x	x
Dimethylvinyl chloride			x
3,7-Dinitrofluoranthene		x	

SUBSTANCE	OSHA	IARC	NTP
3,9-Dinitrofluoranthene		x	
1,6-Dinitropyrene		x	x
1,8-Dinitropyrene		x	x
2,4-Dintrotoluene		x	
2,6-Dintrotoluene		x	
1,4-Dioxane		x	x
Disperse Blue 1		x	x
Dyes metabolized to 3,3'-Dimethoxybenzidine		x	x
Dyes metabolized to 3,3'-Dimethylbenzidine		x	x
Dyes metabolized to benzidine		x	x
Epichlorohydrin		x	x
1,2 Epoxybutane		x	
Erionite		x	x
Estrogens, nonsteroidal		x	
Estrogens, steroidal		x	x
Ethyl acrylate		x	
Ethylbenzene		x	
Ethylene dibromide		x	
Ethyleneimine	x		
N-ethyl-N-nitrosourea		x	
Ethylene oxide	x	x	x
Ethylene thiourea			x
di(2-Ethylhexyl) phthalate			x
Ethyl methanesulfonate		x	x
Etoposide		x	
Formaldehyde (gas)	x	x	x
2-(2-Formylhydrazino)-4-(5-nitro-2-furly) thiazole		x	
Fumonisin B1		x	
Furan		x	x
Fusarium moniliforme, toxins derived from (fumonisin B1, fumonisin B2, and fusarin C)		x	
Galium arsenide		x	
Gasoline		x	
Glass wool (respirable size)			x
Glu-P-2 (2-aminodipyrido[1,2-a:3',2'-*d*]imidazole		x	
Glu-P-1 (2-amino-6-methyldipyrido-1,2-a:3',2'-*d*]imidazole)		x	
Glycidaldehyde		x	
Glycidol		x	x
Griseofulvin		x	
HC Blue No. 1		x	
Heptachlor		x	
Hexachlorobenzene		x	x
Hexachlorocyclohexanes		x	
Hexachloroethane		x	x
Hexamethyl-phosphoramide		x	x
Hydrazine and hydrazine sulfate		x	x
Hydrazobenzene			x
1-Hydroxyanthraquinone		x	

SUBSTANCE	OSHA	IARC	NTP
Indeno [1,2,3-*cd*] pyrene		x	x
Indium phosphide		x	
Iron dextran complex		x	x
IQ (2-amino-3-methylimidazo[4,5-*f*]quinoline		x	
Isoprene		x	x
Kepone (Chlordecone)			x
Lasiocarpine		x	
Lead and lead compounds, inorganic		x	x
Lindane and other hexachlorocyclohexane isomers			x
Magenta (containing CI Basic red 9)		x	
MeA-aplha-c (2-amino-3-methyl-9*h*-pyrido-[2,3-*b*] indole		x	
Medroxyprogesterone acetate		x	
MeIQ (2-amino-3,4-dimethylimidazo [4,5-*f*] Quinoline)		x	
MeIQx (2-amino-3,8-dimethylimidazo[4,5-*f*] quinoxaline)		x	
Melphalan		x	x
Merphalan		x	
Methoxsalen with ultraviolet A therapy (PUVA)		x	x
2-Methylaziridine (Propylenimine)		x	x
5-Methoxypsoralen (methoxsalen)		x	
8-Methoxypsoralen (methoxsalen)		x	
Methylarsenic acid		x	
2- Methylaziridine (propyleneimine)		x	x
Methylazoxymethanol acetate		x	
5-Methylchrysene		x	x
Methyl chloromethyl ether		x	x
4,4'-Methylenebis (2-chloroaniline) (MOCA)		x	x
4,4'-Methylenebis (*N*,*N*-dimethylbenzenamine)		x	x
4,4'-Methylenebis (2-methylaniline)		x	
Methylene chloride (dicholoromethane)	x	x	x
Methylenedianiline	x		
4,4'-Methylenedianiline and its dihydrochloride salt		x	x
Methyleugenol			x
Methyl chloromethyl ether (Chloromethyl methyl ether)	x	x	x
Methylmercury compounds		x	
Methyl methanesulfonate		x	x
2-Methyl-1-nitroanthraquinone		x	
N-Methyl-*N'*-nitro-*N*-nitrosoguanidine (MNNG)		x	x
N-Methyl-*N*-nitrosourea		x	
N-methyl-*N*'-nitrosourethane		x	
Methylthiouracil		x	
Metronidazole		x	x
Michler's base (4,4'-methylenebis(N,N-dimethyl)-benzenamine)		x	x
Michler's ketone (4,4'-(Dimethylamino)benzophenone)			x
Microcystin-LR		x	
Mirex		x	x
Mitomycin C		x	
Mitoxantrone		x	
Monocrotaline		x	

SUBSTANCE	OSHA	IARC	NTP
MOPP and other combined chemotherapy including alkylating agents		x	
5-Morpholinomethyl)-3-[(5-nitrofurfurylidene)amino-] 2-oxazolidinone		x	
Mustard gas		x	x
Nafenopin		x	
Napthalene		x	x
α-Naphthylamine	x		
β-Naphthylamine	x		
2-Naphthylamine		x	x
Nickel and certain nickel compounds		x	x
Niridazole		x	
Nitrilotriacetic acid		x	x
5-Nitroacenaphthene		x	
2-Nitroanisole		x	
o-Nitroanisole			x
Nitroarenes (selected)		x	x
Nitrobenzene		x	x
4-Nitrobiphenyl	x		
6- Nitrochrysene		x	x
Nitrofen (2,4-Dichlorophenyl-*p*-nitrophenyl ether)		x	x
2-Nitrofluorene		x	
1-[(5-Nitrofurfurylidene)amino]-2-imidazolidinone		x	
N-[4-(5-Nitro-2-furyl)-2-thiazolyl] acetamide		x	
Nitrogen mustard		x	
Nitrogen mustard hydrochloride			x
Nitrogen mustard N-oxide		x	
Nitromethane		x	x
2-Nitropropane		x	x
1-Nitropyrene		x	x
4-Nitropyrene		x	x
N-Nitrosodi-*n*-butylamine		x	x
N-Nitrosodiethanolamine		x	x
N-Nitrosodiethylamine		x	x
N-Nitrosodimethylamine	x	x	x
N-Nitrosodi-*n*-propylamine		x	x
N-Nitroso-*N*-ethylurea			x
3-(*N*-Nitrosomethylamino) propionitrile		x	
4-(*N*-Nitrosomethyl-amino)-1(3-pyridyl)-1-butanone (NNK)		x	x
N-Nitrosomethylethylamine		x	
N-Nitroso-*N*-methylurea			x
N-Nitrosomethylvinylamine		x	x
N-Nitrosomorpholine		x	x
N-Nitrosonornicotine (NNN)		x	x
N-Nitrosopiperdine		x	x
N-Nitrosopyrrolidine		x	x
N-Nitrososarcosine		x	x
O-Nitrotoluene			x
Norethisterone			x

SUBSTANCE	OSHA	IARC	NTP
Ochratoxin A		x	x
Oestrogens, nonsteriodal		x	
Oestrogens, steroidal		x	
Oil orange SS		x	
Oral contraceptives, combined		x	
Oral contraceptives, sequential		x	
Oxazepam		x	
4,4'-Oxydianiline			x
Oxymetholone			x
Palygorskite (attapulgite)		x	
Panfuran S (containing dihydroxmethyl-Furatrizine)		x	
2,3,4,7,8-Pentachlorodibenzofuran		x	
3,4,5,3',4'-Pentachlorobiphenyl (PCB-126)		x	
Phenacetin and analgesic mixtures containing phenacetin		x	x
Phenazopyridine hydrochloride		x	x
Phenobarbital		x	
Phenolphthalein		x	x
Phenoxybenzamine hydrochloride		x	x
Phenyl glycidyl ether		x	
Phenytoin		x	x
Phosphorus–32		x	
Plutonium-239		x	
Polybrominated biphenyls (PBBs)		x	x
Polychlorinated biphenyls (PCBs)		x	x
Polychlorophenols and their sodium salts		x	
Ponceau MX		x	
Ponceau 3R		x	
Potassium bromate		x	
Procarbazine hydrochloride		x	x
Proflavine salts		x	
Progesterone			x
Progestins		x	
1,3-Propane sultone		x	x
β-Propiolactone	x	x	x
Propylene oxide		x	x
Propylthiouracil		x	x
Radioiodines		x	
Radionuclides (alpha & beta emitting)		x	
Radium-224, 226, 228		x	
Radon-222		x	
Riddelliine		x	x
Reserpine			x
Safrole		x	x
Selenium sulfide			x
Semustine [1-(2-Chloroethyl)-3-(4-methylcyclohexyl)-1-nitrosourea, Methyl-CCNU]		x	
Silca, crystalline (respirable size)		x	x
Sodium-*o*-phenylphenate		x	

SUBSTANCE	OSHA	IARC	NTP
Sterigmatocystin		x	
Streptozotocin		x	x
Styrene		x	
Styrene-7,8-oxide		x	x
Sulfallate		x	x
Sulfur mustard		x	
Talc (containing asbestiform fibers)		x	
Tamoxifen		x	x
Teniposide		x	
2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD)		x	x
Tetrachloroethylene (Perchloroethylene)		x	x
Tetrafluoroethylene		x	x
Tetranitromethane		x	x
Thioacetamide		x	x
4,4'-Thiodianiline		x	x
Thiotepa		x	x
Thiouracil		x	
Thiourea			x
Thorium-232 & decay products		x	
Thorium dioxide		x	
Titanium dioxide		x	
Toluene diisocyanate		x	x
o-Toluidine and *o*-toluidine hydrochloride		x	x
Toxaphene			x
Tresulfan (treosulfan)		x	
Trichloroethylene		x	x
Trichloromethine (trimustine hydrochloride)		x	
2,4,6-Trichlorophenol			x
1,2,3-Trichloropropane		x	x
tris (1-aziridinyl) phosphine sulfide (thiotepa)		x	x
tris (2,3-dibromopropyl) phosphate		x	x
TRP-P-1 (3-amino-1,4-dimethyl-5*h*-pyrido [4,3-*b*] indole)		x	
TRP-P-2 (3-amino-1-methyl-5*h*-pyrido [4,3-*b*] indole)		x	
Trypan blue		x	
Uracil mustard		x	
Urethane		x	x
Vanadium pentoxide		x	
Vinyl acetate		x	
Vinyl bromide		x	x
Vinyl chloride (Chloroethylene)	x	x	x
4-Vinylcyclohexene		x	
4-Vinylcyclohexene diepoxide		x	
4-Vinyl-1-cyclohexene diepoxide			x
Vinyl fluoride		x	x
Zalcitabine		x	
Zidovudine		x	

SUBSTANCE	OSHA	IARC	NTP
Mixtures, processes, biological agents and other materials:			
Acid mists, strong inorganic		x	
Alcoholic beverages		x	
Aluminum production		x	
Analgesic mixtures containing phenacetin		x	
Areca nut		x	
Betal quid (betal leaf mixture)		x	
Biomass fuel (primarily wood), indoor emissions from household combustion		x	
Bitumens		x	
Carrageenan, degraded		x	
Carbon electode manufacture		x	
Chlorinated paraffins of average carbon chain length C_{12} and approximately 60% chlorination		x	
Clonorchis sinensis (infection with)		x	
Coal gasification		x	
Coal tars and coal tar pitches		x	x
Coal tar distillation		x	
Coke oven emissions	x		x
Creosotes		x	
Diesel engine exhaust		x	
Diesel exhaust particulates			x
Engine exhaust, gasoline		x	
Epstien-Barr virus		x	
Fission products, including strontium-90		x	
Frying, emissions from high temperatures		x	
Fuel oils, residual (heavy)		x	
Gamma radiation and X-radiation		x	x
Glass manufacturing (art glass, containers, pressed ware)		x	
Helicobacter pylori (infection with)		x	
Hematite mining (underground)		x	
Hepatitis B virus		x	x
Hepatitis C virus		x	x
Human immunodeficiency virus type 1 (infection with)		x	
Human immunodeficiency virus type 2 (infection with)		x	
Human papillomavirus (types 16, 18, 31, 33, 35, 39, 45, 51, 52, 58, 59)		x	x
Human papillomavirus (types 26, 53, 66, 67, 70, 73, 82)		x	
Human papillomavirus (types 30, 34, 68, 69, 85, 97)		x	
Human papillomavirus (types 5, 8 in patients with epidermodysplasia verruciformis)		x	
Human papillomaviruses: some genital-mucosal types		x	x
Human T-cell lymphotropic virus (type 1)		x	
Ionizing radiation		x	x
Isopropyl alcohol manufacture using strong acids		x	
Kaposi sarcoma herpes virus		x	
Leather dust		x	
Magnetic Fields (extremely low frequency)		x	
Maté, hot (Yerba)		x	

SUBSTANCE	OSHA	IARC	NTP
Mixtures, processes, biological agents and other materials:			
Mineral oils, untreated and mildly treated		x	x
Neutrons		x	
Nitrate or nitrite (ingested) under conditions that result in endogenous nitrosation		x	
Non-arsenical insecticides (spraying and application)		x	
Opisthorchis viverini (infection with)		x	
Petroleum refining (occupational exposures in)		x	
Polybrominated biphenyls (PBBs)		x	
Polychlorinated biphenyls (PCBs)		x	
Radionuclides (alpha & beta emitting)		x	
Refractory ceramic fibres		x	
Schistosoma haematobium (infection with)		x	
Schistosoma japonicum (infection with)		x	
Shale-oils		x	
Solar radiation (and sunlamps)		x	
Soots			x
Special purpose fibres such as E-glass and '475'glass fibres		x	
Strong inorganic acid mists containing sulfuric acid			x
Tobacco smoke, environmental tobacco smoke, & smokeless tobacco		x	x
Toxaphene (chlorinated camphenes)		x	
Toxins derived from *fusarium moniliforme*		x	
Ultraviolet radiation (broad spectrum)	x	x	x
Ultraviolet radiation A, B, & C		x	x
Welding fumes		x	
Wood Dust		x	x

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APPENDIX F: REPRODUCTIVE TOXINS

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EXAMPLES OF REPRODUCTIVE TOXINS[1]

Drugs and Environmental Chemicals:

Acetaldehyde Acetonitrile Acrolein Aminopterin
Androgenic hormones Arsenic (elemental/organic) Benzene
Benzo(*a*)pyrene Boric acid Busulfan
tert-Butly alcohol Cadmium Calcium arsenate Carbon Disulfide Chlorobiphenyls
Chloroform
Coumarin anticoagulants
Cyclophosphamide
DDT
Dibenzofuran
Diethylstilbestrol
Dimethyl mercury
Dinitrogen pentoxide
Diphenylhydantoin
Ethidium Bromide
Ethylene glycol Ethylene oxide Ethylene dibromide
Ethyl methane sulfonate
Etretinate
5-Fluorouracil
Glycol ether
Hydrazine
Isocyanate, Methyl-
Lead compounds
Lithium
Methotrexate Methylaminopterin Methylene chloride Methylmercury Mercury, organic
Penicillamine Phthalate, dubutyl- Perchloroethylene
Polychlorinated biphenyls
13-cis-Retionic acid (Isotretinoin and Accutane)
Tetracyclines
Thalidomide
Toluene
Trimethadoine
Valproic acid
Vinyl chloride
Xylene, *o-*, *m-*, *p-*
Zinc sulfate

Infectious Agents: Cytomegalovirus (CVM)
Parvovirus B-19
Rubella virus
Syphilis
Toxoplasmosis
Varicella virus
Venezuelan equine encephalitis virus

Radiation: Ionizing radiation

[1]References: Shepard, T.H., *Catalog of Teratogenic Agents*, 8th eds. Baltimore: John Hopkins University Press, 1995.

Jankovic, J. and Drake, F., A screening method for occupational reproductive health risk, *American Industrial Hygiene Association Journal*, 57:641-649, 1996.

APPENDIX G: ACUTELY TOXIC CHEMICALS

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EXAMPLES OF ACUTELY TOXIC CHEMICALS

EXAMPLES	IDLH[1]
Acrolein	2 ppm
Arsine	3 ppm
Chlorine	10 ppm
Diazomethane	2 ppm
Diborane (gas)	15 ppm
Hydrogen cyanide	50 ppm
Hydrogen fluoride	30 ppm
Methyl fluorosulfonate	5 ppm
Methyl isocyanate	3 ppm
Nickel carbonyl	2 ppm
Nitrogen dioxide	20 ppm
Osmium tetroxide	1 mg/m^3
Ozone	5 ppm
Phosgene	2 ppm
Sodium azide	20 ppm
Sodium cyanide (as CN)	25 mg/m^3

[1] IDLH - Immediately Dangerous to Life and Health (IDLH), values based on Lethal Concentrations or Dose (LC_{50} or LD_{50}), National Institute of Occupational Safety and Health (NIOSH), *Pocket Guide to Chemical Hazards*, 2004.

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APPENDIX H: 29CFR 1910.1450 OSHA LABORATORY STANDARD

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• Part Number:	1910
• Part Title:	Occupational Safety and Health Standards
• Subpart:	Z
• Subpart Title:	Toxic and Hazardous Substances
• Standard Number:	1910.1450
• Title:	Occupational exposure to hazardous chemicals in laboratories.

1910.1450(a)

Scope and application.

1910.1450(a)(1)

This section shall apply to all employers engaged in the laboratory use of hazardous chemicals as defined below.

1910.1450(a)(2)

Where this section applies, it shall supersede, for laboratories, the requirements of all other OSHA health standards in 29 CFR part 1910, subpart Z, except as follows:

1910.1450(a)(2)(i)

For any OSHA health standard, only the requirement to limit employee exposure to the specific permissible exposure limit shall apply for laboratories, unless that particular standard states otherwise or unless the conditions of paragraph (a)(2)(iii) of this section apply.

1910.1450(a)(2)(ii)

Prohibition of eye and skin contact where specified by any OSHA health standard shall be observed.

1910.1450(a)(2)(iii)

Where the action level (or in the absence of an action level, the permissible exposure limit) is routinely exceeded for an OSHA regulated substance with exposure monitoring and medical surveillance requirements paragraphs (d) and (g)(1)(ii) of this section shall apply.

1910.1450(a)(3)

This section shall not apply to:

1910.1450(a)(3)(i)

Uses of hazardous chemicals which do not meet the definition of laboratory use, and in such cases, the employer shall comply with the relevant standard in 29 CFR part 1910, subpart Z, even if such

use occurs in a laboratory.

1910.1450(a)(3)(ii)

Laboratory uses of hazardous chemicals which provide no potential for employee exposure. Examples of such conditions might include:

1910.1450(a)(3)(ii)(A)

Procedures using chemically-impregnated test media such as Dip-and-Read tests where a reagent strip is dipped into the specimen to be tested and the results are interpreted by comparing the color reaction to a color chart supplied by the manufacturer of the test strip; and

1910.1450(a)(3)(ii)(B)

Commercially prepared kits such as those used in performing pregnancy tests in which all of the reagents needed to conduct the test are contained in the kit.

1910.1450(b)

Definitions —

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

Assistant Secretary means the Assistant Secretary of Labor for Occupational Safety and Health, U.S. Department of Labor, or designee.

Carcinogen (see *select carcinogen*).

Chemical Hygiene Officer means an employee who is designated by the employer, and who is qualified by training or experience, to provide technical guidance in the development and implementation of the provisions of the Chemical Hygiene Plan. This definition is not intended to place limitations on the position description or job classification that the designated indvidual shall hold within the employer's organizational structure.

Chemical Hygiene Plan means a written program developed and implemented by the employer which sets forth procedures, equipment, personal protective equipment and work practices that (i) are capable of protecting employees from the health hazards presented by hazardous chemicals used in that particular workplace and (ii) meets the requirements of paragraph (e) of this section.

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

Employee means an individual employed in a laboratory workplace who may be exposed to hazardous chemicals in the course of his or her assignments.

Hazardous chemical means any chemical which is classified as health hazard or simple asphyxiant in accordance with the Hazard Communication Standard (§1910.1200).

Health hazard means a chemical that is classified as posing one of the following hazardous effects: Acute toxicity (any route of exposure); skin corrosion or irritation; serious eye damage or eye irritation; respiratory or skin sensitization; germ cell mutagenicity; carcinogenity; reproductive toxicity; specific target organ toxicity (single or repeated exposure); aspiration hazard. The criteria for determining whether a chemical is classified as a health hazard are detailed in appendix A of the Hazard Communication Standard (§1910.1200) and §1910.1200(c) (definition of "simple asphyxiant").

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

Laboratory scale means work with substances in which the containers used for reactions, transfers, and other handling of substances are designed to be easily and safely manipulated by one person. "Laboratory scale" excludes those workplaces whose function is to produce commercial quantities of materials.

Laboratory-type hood means a device located in a laboratory, enclosure on five sides with a moveable sash or fixed partial enclosed on the remaining side; constructed and maintained to draw air from the laboratory and to prevent or minimize the escape of air contaminants into the laboratory; and allows chemical manipulations to be conducted in the enclosure without insertion of any portion of the employee's body other than hands and arms.

Walk-in hoods with adjustable sashes meet the above definition provided that the sashes are adjusted during use so that the airflow and the exhaust of air contaminants are not compromised and employees do not work inside the enclosure during the release of airborne hazardous chemicals.

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

(i) Chemical manipulations are carried out on a "laboratory scale;"

(ii) Multiple chemical procedures or chemicals are used;

(iii) The procedures involved are not part of a production process, nor in any way simulate a production process; and

(iv) "Protective laboratory practices and equipment" are available and in common use to minimize the potential for employee exposure to hazardous chemicals.

Medical consultation means a consultation which takes place between an employee and a licensed physician for the purpose of determining what medical examinations or procedures, if any, are appropriate in cases where a significant exposure to a hazardous chemical may have taken place.

Mutagen means chemicals that cause permanent changes in the amount or structure of the genetic material

in a cell. Chemicals classified as mutagens in accordance with the Hazard Communication Standard (§1910.1200) shall be considered mutagens for purposes of this section.

Physical hazard means a chemical that is classified as posing one of the following hazardous effects: Explosive; flammable (gases, aerosols, liquids, or solids); oxidizer (liquid, solid, or gas); self reactive; pyrophoric (gas, liquid or solid); self-heating; organic peroxide; corrosive to metal; gas under pressure; in contact with water emits flammable gas; or combustible dust. The criteria for determining whether a chemical is classified as a physical hazard are in appendix B of the Hazard Communication Standard (§1910.1200) and §1910.1200(c) (definitions of "combustible dust" and "pyrophoric gas").

Protective laboratory practices and equipment means those laboratory procedures, practices and equipment accepted by laboratory health and safety experts as effective, or that the employer can show to be effective, in minimizing the potential for employee exposure to hazardous chemicals.

Reproductive toxins mean chemicals that affect the reproductive capabilities including adverse effects on sexual function and fertility in adult males and females, as well as adverse effects on the development of the offspring. Chemicals classified as reproductive toxins in accordance with the Hazard Communication Standard (§1910.1200) shall be considered reproductive toxins for purposes of this section.

Select carcinogen means any substance which meets one of the following criteria:

(i) It is regulated by OSHA as a carcinogen; or

(ii) It is listed under the category, "known to be carcinogens," in the Annual Report on Carcinogens published by the National Toxicology Program (NTP) (latest edition); or

(iii) It is listed under Group 1 ("carcinogenic to humans") by the International Agency for Research on Cancer Monographs (IARC) (latest editions); or

(iv) It is listed in either Group 2A or 2B by IARC or under the category, "reasonably anticipated to be carcinogens" by NTP, and causes statistically significant tumor incidence in experimental animals in accordance with any of the following criteria:

(A) After inhalation exposure of 6–7 hours per day, 5 days per week, for a significant portion of a lifetime to dosages of less than 10 mg/m^3;

(B) After repeated skin application of less than 300 (mg/kg of body weight) per week; or

(C) After oral dosages of less than 50 mg/kg of body weight per day.

1910.1450(c)

Permissible exposure limits. For laboratory uses of OSHA regulated substances, the employer shall assure that laboratory employees' exposures to such substances do not exceed the permissible exposure limits specified in 29 CFR part 1910, subpart Z.

1910.1450(d)

Employee exposure determination --

1910.1450(d)(1)

Initial monitoring. The employer shall measure the employee's exposure to any substance regulated by a standard which requires monitoring if there is reason to believe that exposure levels for that substance routinely exceed the action level (or in the absence of an action level, the PEL).

1910.1450(d)(2)

Periodic monitoring. If the initial monitoring prescribed by paragraph (d)(1) of this section discloses employee exposure over the action level (or in the absence of an action level, the PEL), the employer shall immediately comply with the exposure monitoring provisions of the relevant standard.

1910.1450(d)(3)

Termination of monitoring. Monitoring may be terminated in accordance with the relevant standard.

1910.1450(d)(4)

Employee notification of monitoring results. The employer shall, within 15 working days after the receipt of any monitoring results, notify the employee of these results in writing either individually or by posting results in an appropriate location that is accessible to employees.

1910.1450(e)

Chemical hygiene plan -- General. (Appendix A of this section is non-mandatory but provides guidance to assist employers in the development of the Chemical Hygiene Plan).

1910.1450(e)(1)

Where hazardous chemicals as defined by this standard are used in the workplace, the employer shall develop and carry out the provisions of a written Chemical Hygiene Plan which is:

1910.1450(e)(1)(i)

Capable of protecting employees from health hazards associated with hazardous chemicals in that laboratory and

1910.1450(e)(1)(ii)

Capable of keeping exposures below the limits specified in paragraph (c) of this section.

1910.1450(e)(2)

The Chemical Hygiene Plan shall be readily available to employees, employee representatives and, upon

request, to the Assistant Secretary.

1910.1450(e)(3)

The Chemical Hygiene Plan shall include each of the following elements and shall indicate specific measures that the employer will take to ensure laboratory employee protection;

1910.1450(e)(3)(i)

Standard operating procedures relevant to safety and health considerations to be followed when laboratory work involves the use of hazardous chemicals;

1910.1450(e)(3)(ii)

Criteria that the employer will use to determine and implement control measures to reduce employee exposure to hazardous chemicals including engineering controls, the use of personal protective equipment and hygiene practices; particular attention shall be given to the selection of control measures for chemicals that are known to be extremely hazardous;

1910.1450(e)(3)(iii)

A requirement that fume hoods and other protective equipment are functioning properly and specific measures that shall be taken to ensure proper and adequate performance of such equipment;

1910.1450(e)(3)(iv)

Provisions for employee information and training as prescribed in paragraph (f) of this section;

1910.1450(e)(3)(v)

The circumstances under which a particular laboratory operation, procedure or activity shall require prior approval from the employer or the employer's designee before implementation;

1910.1450(e)(3)(vi)

Provisions for medical consultation and medical examinations in accordance with paragraph (g) of this section;

1910.1450(e)(3)(vii)

Designation of personnel responsible for implementation of the Chemical Hygiene Plan including the assignment of a Chemical Hygiene Officer, and, if appropriate, establishment of a Chemical Hygiene Committee; and

1910.1450(e)(3)(viii)

Provisions for additional employee protection for work with particularly hazardous substances. These include "select carcinogens," reproductive toxins and substances which have a high degree of acute toxicity. Specific consideration shall be given to the following provisions which shall be

included where appropriate:

1910.1450(e)(3)(viii)(A)

Establishment of a designated area;

1910.1450(e)(3)(viii)(B)

Use of containment devices such as fume hoods or glove boxes;

1910.1450(e)(3)(viii)(C)

Procedures for safe removal of contaminated waste; and

1910.1450(e)(3)(viii)(D)

Decontamination procedures.

1910.1450(e)(4)

The employer shall review and evaluate the effectiveness of the Chemical Hygiene Plan at least annually and update it as necessary.

1910.1450(f)

Employee information and training.

1910.1450(f)(1)

The employer shall provide employees with information and training to ensure that they are apprised of the hazards of chemicals present in their work area.

1910.1450(f)(2)

Such information shall be provided at the time of an employee's initial assignment to a work area where hazardous chemicals are present and prior to assignments involving new exposure situations. The frequency of refresher information and training shall be determined by the employer.

1910.1450(f)(3)

Information. Employees shall be informed of:

1910.1450(f)(3)(i)

The contents of this standard and its appendices which shall be made available to employees;

1910.1450(f)(3)(ii)

the location and availability of the employer's Chemical Hygiene Plan;

1910.1450(f)(3)(iii)

The permissible exposure limits for OSHA regulated substances or recommended exposure limits for other hazardous chemicals where there is no applicable OSHA standard;

1910.1450(f)(3)(iv)

Signs and symptoms associated with exposures to hazardous chemicals used in the laboratory; and

1910.1450(f)(3)(v)

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, safety data sheets received from the chemical supplier.

1910.1450(f)(4)

Training.

1910.1450(f)(4)(i)

Employee training shall include:

1910.1450(f)(4)(i)(A)

Methods and observations that may be used to detect the presence or release of a hazardous chemical (such as monitoring conducted by the employer, continuous monitoring devices, visual appearance or odor of hazardous chemicals when being released, etc.);

1910.1450(f)(4)(i)(B)

The physical and health hazards of chemicals in the work area; and

1910.1450(f)(4)(i)(C)

The measures employees can take to protect themselves from these hazards, including specific procedures the employer has implemented to protect employees from exposure to hazardous chemicals, such as appropriate work practices, emergency procedures, and personal protective equipment to be used.

1910.1450(f)(4)(ii)

The employee shall be trained on the applicable details of the employer's written Chemical Hygiene Plan.

1910.1450(g)

Medical consultation and medical examinations.

1910.1450(g)(1)

The employer shall provide all employees who work with hazardous chemicals an opportunity to receive medical attention, including any follow-up examinations which the examining physician determines to be necessary, under the following circumstances:

1910.1450(g)(1)(i)

Whenever an employee develops signs or symptoms associated with a hazardous chemical to which the employee may have been exposed in the laboratory, the employee shall be provided an opportunity to receive an appropriate medical examination.

1910.1450(g)(1)(ii)

Where exposure monitoring reveals an exposure level routinely above the action level (or in the absence of an action level, the PEL) for an OSHA regulated substance for which there are exposure monitoring and medical surveillance requirements, medical surveillance shall be established for the affected employee as prescribed by the particular standard.

1910.1450(g)(1)(iii)

Whenever an event takes place in the work area such as a spill, leak, explosion or other occurrence resulting in the likelihood of a hazardous exposure, the affected employee shall be provided an opportunity for a medical consultation. Such consultation shall be for the purpose of determining the need for a medical examination.

1910.1450(g)(2)

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

1910.1450(g)(3)

Information provided to the physician. The employer shall provide the following information to the physician:

1910.1450(g)(3)(i)

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

1910.1450(g)(3)(ii)

A description of the conditions under which the exposure occurred including quantitative exposure

data, if available; and

1910.1450(g)(3)(iii)

A description of the signs and symptoms of exposure that the employee is experiencing, if any.

1910.1450(g)(4)

Physician's written opinion.

1910.1450(g)(4)(i)

For examination or consultation required under this standard, the employer shall obtain a written opinion from the examining physician which shall include the following:

1910.1450(g)(4)(i)(A)

Any recommendation for further medical follow-up;

1910.1450(g)(4)(i)(B)

The results of the medical examination and any associated tests;

1910.1450(g)(4)(i)(C)

Any medical condition which may be revealed in the course of the examination which may place the employee at increased risk as a result of exposure to a hazardous workplace; and

1910.1450(g)(4)(i)(D)

A statement that the employee has been informed by the physician of the results of the consultation or medical examination and any medical condition that may require further examination or treatment.

1910.1450(g)(4)(ii)

The written opinion shall not reveal specific findings of diagnoses unrelated to occupational exposure.

1910.1450(h)

Hazard identification.

1910.1450(h)(1)

With respect to labels and safety data sheets:

1910.1450(h)(1)(i)

Employers shall ensure that labels on incoming containers of hazardous chemicals are not removed or defaced.

1910.1450(h)(1)(ii)

Employers shall maintain any safety data sheets that are received with incoming shipments of hazardous chemicals, and ensure that they are readily accessible to laboratory employees.

1910.1450(h)(2)

The following provisions shall apply to chemical substances developed in the laboratory:

1910.1450(h)(2)(i)

If the composition of the chemical substance which is produced exclusively for the laboratory's use is known, the employer shall determine if it is a hazardous chemical as defined in paragraph (b) of this section. If the chemical is determined to be hazardous, the employer shall provide appropriate training as required under paragraph (f) of this section.

1910.1450(h)(2)(ii)

If the chemical produced is a byproduct whose composition is not known, the employer shall assume that the substance is hazardous and shall implement paragraph (e) of this section.

1910.1450(h)(2)(iii)

If the chemical substance is produced for another user outside of the laboratory, the employer shall comply with the Hazard Communication Standard (29 CFR 1910.1200) including the requirements for preparation of safety data sheets and labeling.

1910.1450(i)

Use of respirators. Where the use of respirators is necessary to maintain exposure below permissible exposure limits, the employer shall provide, at no cost to the employee, the proper respiratory equipment. Respirators shall be selected and used in accordance with the requirements of 29 CFR 1910.134.

1910.1450(j)

Recordkeeping.

1910.1450(j)(1)

The employer shall establish and maintain for each employee an accurate record of any measurements taken to monitor employee exposures and any medical consultation and examinations including tests or written opinions required by this standard.

1910.1450(j)(2)

The employer shall assure that such records are kept, transferred, and made available in accordance with 29

CFR 1910.1020.

1910.1450(k)

[Reserved]

1910.1450(l)

Appendices. The information contained in the appendices is not intended, by itself, to create any additional obligations not otherwise imposed or to detract from any existing obligation.

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• **Subpart Title:**	Toxic and Hazardous Substances
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• **Title:**	National Research Council Recommendations Concerning Chemical Hygiene in Laboratories (Non-Mandatory)

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Foreword

As guidance for each employer's development of an appropriate laboratory Chemical Hygiene Plan, the following non-mandatory recommendations are provided. They were extracted form "Prudent Practices" for Handling Hazardous Chemicals in Laboratories" (referred to below as "Prudent Practices"), which was published in 1981 by the National Research Council and is available from the National Academy Press, 2101 Constitution Ave., NW,. Washington DC 20418.

"Prudent Practices" is cited because of its wide distribution and acceptance and because of its preparation by members of the laboratory community through the sponsorship of the National Research Council. However, none of the recommendations given here will modify any requirements of the laboratory standard. This Appendix merely presents pertinent recommendations from "Prudent Practices", organized into a form convenient for quick reference during operation of a laboratory facility and during development and application of a Chemical Hygiene Plan. Users of this appendix should consult "Prudent Practices" for a more extended presentation and justification for each recommendation.

"Prudent Practices" deal with both safety and chemical hazards while the laboratory standard is concerned primarily with chemical hazards. Therefore, only those recommendations directed primarily toward control of toxic exposures are cited in this appendix, with the term "chemical Hygiene" being substituted for the word "safety". However, since conditions producing or threatening physical injury often pose toxic risks as well, page references concerning major categories of safety hazards in the laboratory are given in section F.

The recommendations from "Prudent Practices" have been paraphrased, combined, or otherwise reorganized, and headings have been added. However, their sense has not been changed.

Corresponding Sections of the Standard and this Appendix

The following table is given for the convenience of those who are developing a Chemical Hygiene Plan which will satisfy the requirements of paragraph (e) of the standard. It indicates those sections of this appendix which are most pertinent to each of the sections of paragraph (e) and related paragraphs.

Paragraph and topic in laboratory standard	Relevant appendix section
(e)(3)(i) Standard operating procedures for handling toxic chemicals.	C, D, E
(e)(3)(ii) Criteria to be used for implementation of measures to reduce exposures.	D
(e)(3)(iii) Fume hood performance	C4b
(e)(3)(iv) Employee information and training (including emergency procedures).	D10, D9
(e)(3)(v) Requirements for prior approval of laboratory activities.	E2b, E4b
(e)(3)(vi) Medical consultation and medical examinations.	D5, E4f
(e)(3)(vii) Chemical hygiene responsibilities.	B
(e)(3)(viii) Special precautions for work with particularly hazardous substances.	E2, E3, E4

In this appendix, those recommendations directed primarily at administrators and supervisors are given in sections A-D. Those recommendations of primary concern to employees who are actually handling laboratory chemicals are given in section E. (Reference to page numbers in "Prudent Practices" are given in parentheses.)

A. General Principles for Work with Laboratory Chemicals

In addition to the more detailed recommendations listed below in sections B-E, "Prudent Practices" expresses certain general principles, including the following:

1. It is prudent to minimize all chemical exposures. Because few laboratory chemicals are without hazards, general precautions for handling all laboratory chemicals should be adopted, rather than specific guidelines for particular chemicals (2,10). Skin contact with chemicals should be avoided as a cardinal rule (198).

2. Avoid underestimation of risk. Even for substances of no known significant hazard, exposure should be minimized; for work with substances which present special hazards, special precautions should be taken (10, 37, 38). One should assume that any mixture will be more toxic than its most toxic component (30, 103) and that all substances of unknown toxicity are toxic (3, 34).

3. Provide adequate ventilation. The best way to prevent exposure to airborne substances is to prevent their escape into the working atmosphere by use of hoods and other ventilation devices (32, 198).

4. Institute a chemical hygiene program. A mandatory chemical hygiene program designed to minimize exposures is needed; it should be a regular, continuing effort, not merely a standby or short-term activity (6,11). Its recommendations should be followed in academic teaching laboratories as well as by full-time laboratory workers (13).

5. Observe the PELs, TLVs. The Permissible Exposure Limits of OSHA and the Threshold Limit Values of the American Conference of Governmental Industrial Hygienists should not be exceeded (13).

B. Chemical Hygiene Responsibilities

Responsibility for chemical hygiene rests at all levels (6, 11, 21) including the:

1. Chief executive officer, who has ultimate responsibility for chemical hygiene within the institution and must, with other administrators, provide continuing support for institutional chemical hygiene (7, 11).

2. Supervisor of the department or other administrative unit, who is responsible for chemical hygiene in that unit (7).

3. chemical hygiene officer(s), whose appointment is essential (7) and who must:

(a) Work with administrators and other employees to develop and implement appropriate chemical hygiene policies and practices (7);

(b) Monitor procurement, use, and disposal of chemicals used in the lab (8);

(c) See that appropriate audits are maintained (8);

(d) Help project directors develop precautions and adequate facilities (10);

(e) Know the current legal requirements concerning regulated substances (50); and

(f) Seek ways to improve the chemical hygiene program (8, 11).

4. Laboratory supervisor, who has overall responsibility for chemical hygiene in the laboratory (21) including responsibility to:

(a) Ensure that workers know and follow the chemical hygiene rules, that protective equipment is available and in working order, and that appropriate training has been provided (21, 22);

(b) Provide regular, formal chemical hygiene and housekeeping inspections including routine inspections of emergency equipment (21, 171);

(c) Know the current legal requirements concerning regulated substances (50, 231);

(d) Determine the required levels of protective apparel and equipment (156, 160, 162); and

(e) Ensure that facilities and training for use of any material being ordered are adequate (215).

5. Project director or director of other specific operation, who has primary responsibility for chemical hygiene procedures for that operation (7).

6. Laboratory worker, who is responsible for:

(a) Planning and conducting each operation in accordance with the institutional chemical hygiene procedures (7, 21, 22, 230); and

(b) Developing good personal chemical hygiene habits (22).

C. The Laboratory Facility

1. Design. The laboratory facility should have:

(a) An appropriate general ventilation system (see C4 below) with air intakes and exhausts located so as to avoid intake of contaminated air (194);

(b) Adequate, well-ventilated stockrooms/storerooms (218, 219).

(c) Laboratory hoods and sinks (12, 162);

(d) Other safety equipment including eyewash fountains and drench showers (162, 169); and

(e) Arrangements for waste disposal (12, 240).

2. Maintenance. Chemical-hygiene-related equipment (hoods, incinerator, etc.) should undergo continual appraisal and be modified if inadequate (11, 12).

3. Usage. The work conducted (10) and its scale (12) must be appropriate to the physical facilities available and, especially, to the quality of ventilation (13).

4. Ventilation - (a) General laboratory ventilation. This system should: Provide a source of air for breathing and for input to local ventilation devices (199); it should not be relied on for protection from toxic substances released into the laboratory (198); ensure that laboratory air is continually replaced, preventing increase of air concentrations of toxic substances during the working day (194); direct air flow into the laboratory from non-laboratory areas and out to the exterior of the building (194).

(b) Hoods. A laboratory hood with 2.5 linear feet of hood space per person should be provided for every 2 workers if they spend most of their time working with chemicals (199); each hood should have a continuous monitoring device to allow convenient confirmation of adequate hood performance before use (200, 209). If this is not possible, work with substances of unknown toxicity should be avoided (13) or other types of local ventilation devices should be provided (199). See pp. 201-206 for a discussion of hood design, construction, and evaluation.

(c) Other local ventilation devices. Ventilated storage cabinets, canopy hoods, snorkels, etc. should be provided as needed (199). Each canopy hood and snorkel should have a separate exhaust duct (207).

(d) Special ventilation areas. Exhaust air from glove boxes and isolation rooms should be passed through scrubbers or other treatment before release into the regular exhaust system (208). Cold rooms and warm rooms should have provisions for rapid escape and for escape in the event of electrical failure (209).

(e) Modifications. Any alteration of the ventilation system should be made only if thorough testing indicates that worker protection from airborne toxic substances will continue to be adequate (12, 193, 204).

(f) Performance. Rate: 4-12 room air changes/hour is normally adequate general ventilation if local exhaust systems such as hoods are used as the primary method of control (194).

(g) Quality. General air flow should not be turbulent and should be relatively uniform throughout the laboratory, with no high velocity or static areas (194, 195); airflow into and within the hood should not be excessively turbulent (200); hood face velocity should be adequate (typically 60-100 lfm) (200, 204).

(h) Evaluation. Quality and quantity of ventilation should be evaluated on installation (202), regularly monitored (at least every 3 months) (6, 12, 14, 195), and reevaluated whenever a change in local ventilation devices is made (12, 195, 207). See pp 195-198 for methods of evaluation and for calculation of estimated airborne contaminant concentrations.

D. Components of the Chemical Hygiene Plan

1. Basic Rules and Procedures (Recommendations for these are given in section E, below)

2. Chemical Procurement, Distribution, and Storage

(a) Procurement. Before a substance is received, information on proper handling, storage, and disposal should be known to those who will be involved (215, 216). No container should be accepted without an adequate identifying label (216). Preferably, all substances should be received in a central location (216).

(b) Stockrooms/storerooms. Toxic substances should be segregated in a well-identified area with local exhaust ventilation (221). Chemicals which are highly toxic (227) or other chemicals whose containers have been opened should be in unbreakable secondary containers (219). Stored chemicals should be examined periodically (at least annually) for replacement, deterioration, and container integrity (218-19).

Stockrooms/storerooms should not be used as preparation or repackaging areas, should be open during normal working hours, and should be controlled by one person (219).

(c) Distribution. When chemicals are hand carried, the container should be placed in an outside container or bucket. Freight-only elevators should be used if possible (223).

(d) Laboratory storage. Amounts permitted should be as small as practical. Storage on bench tops and in hoods is inadvisable. Exposure to heat or direct sunlight should be avoided. Periodic inventories should be conducted, with unneeded items being discarded or returned to the storeroom/stockroom (225-6, 229).

3. Environmental Monitoring

Regular instrumental monitoring of airborne concentrations is not usually justified or practical in laboratories but may be appropriate when testing or redesigning hoods or other ventilation devices (12) or when a highly toxic substance is stored or used regularly (e.g., 3 times/week) (13).

4. Housekeeping, Maintenance, and Inspections

(a) Cleaning. Floors should be cleaned regularly (24).

(b) Inspections. Formal housekeeping and chemical hygiene inspections should be held at least quarterly (6, 21) for units which have frequent personnel changes and semiannually for others; informal inspections should be continual (21).

(c) Maintenance. Eye wash fountains should be inspected at intervals of not less than 3 months (6). Respirators for routine use should be inspected periodically by the laboratory supervisor (169). Other safety equipment should be inspected regularly. (e.g., every 3-6 months) (6, 24, 171). Procedures to prevent restarting of out-of-service equipment should be established (25).

(d) Passageways. Stairways and hallways should not be used as storage areas (24). Access to exits,

emergency equipment, and utility controls should never be blocked (24).

5. Medical Program

(a) Compliance with regulations. Regular medical surveillance should be established to the extent required by regulations (12).

(b) Routine surveillance. Anyone whose work involves regular and frequent handling of toxicologically significant quantities of a chemical should consult a qualified physician to determine on an individual basis whether a regular schedule of medical surveillance is desirable (11, 50).

(c) First aid. Personnel trained in first aid should be available during working hours and an emergency room with medical personnel should be nearby (173). See pp. 176-178 for description of some emergency first aid procedures.

6. Protective Apparel and Equipment

These should include for each laboratory:

(a) Protective apparel compatible with the required degree of protection for substances being handled (158-161);

(b) An easily accessible drench-type safety shower (162, 169);

(c) An eyewash fountain (162)

(d) A fire extinguisher (162-164);

(e) Respiratory protection (164-9), fire alarm and telephone for emergency use (162) should be available nearby; and

(f) Other items designated by the laboratory supervisor (156, 160).

7. Records

(a) Accident records should be written and retained (174).

(b) Chemical Hygiene Plan records should document that the facilities and precautions were compatible with current knowledge and regulations (7).

(c) Inventory and usage records for high-risk substances should be kept as specified in sections E3e below.

(d) Medical records should be retained by the institution in accordance with the requirements of state and federal regulations (12).

8. Signs and Labels

Prominent signs and labels of the following types should be posted:

(a) Emergency telephone numbers of emergency personnel/facilities, supervisors, and laboratory workers (28);

(b) Identity labels, showing contents of containers (including waste receptacles) and associated hazards (27, 48);

(c) Location signs for safety showers, eyewash stations, other safety and first aid equipment, exits (27) and areas where food and beverage consumption and storage are permitted (24); and

(d) Warnings at areas or equipment where special or unusual hazards exist (27).

9. Spills and Accidents

(a) A written emergency plan should be established and communicated to all personnel; it should include procedures for ventilation failure (200), evacuation, medical care, reporting, and drills (172).

(b) There should be an alarm system to alert people in all parts of the facility including isolation areas such as cold rooms (172).

(c) A spill control policy should be developed and should include consideration of prevention, containment, cleanup, and reporting (175).

(d) All accidents or near accidents should be carefully analyzed with the results distributed to all who might benefit (8, 28).

10. Information and Training Program

(a) Aim: To assure that all individuals at risk are adequately informed about the work in the laboratory, its risks, and what to do if an accident occurs (5, 15).

(b) Emergency and Personal Protection Training: Every laboratory worker should know the location and proper use of available protective apparel and equipment (154, 169).

Some of the full-time personnel of the laboratory should be trained in the proper use of emergency equipment and procedures (6).

Such training as well as first aid instruction should be available to (154) and encouraged for (176) everyone who might need it.

(c) Receiving and stockroom/storeroom personnel should know about hazards, handling equipment, protective apparel, and relevant regulations (217).

(d) Frequency of Training: The training and education program should be a regular, continuing activity - not simply an annual presentation (15).

(e) Literature/Consultation: Literature and consulting advice concerning chemical hygiene should be readily available to laboratory personnel, who should be encouraged to use these information resources (14).

11. Waste Disposal Program.

(a) Aim: To assure that minimal harm to people, other organisms, and the environment will result from the disposal of waste laboratory chemicals (5).

(b) Content (14, 232, 233, 240): The waste disposal program should specify how waste is to be collected, segregated, stored, and transported and include consideration of what materials can be incinerated. Transport from the institution must be in accordance with DOT regulations (244).

(c) Discarding Chemical Stocks: Unlabeled containers of chemicals and solutions should undergo prompt disposal; if partially used, they should not be opened (24, 27).

Before a worker's employment in the laboratory ends, chemicals for which that person was responsible should be discarded or returned to storage (226).

(d) Frequency of Disposal: Waste should be removed from laboratories to a central waste storage area at least once per week and from the central waste storage area at regular intervals (14).

(e) Method of Disposal: Incineration in an environmentally acceptable manner is the most practical disposal method for combustible laboratory waste (14, 238, 241).

Indiscriminate disposal by pouring waste chemicals down the drain (14, 231, 242) or adding them to mixed refuse for landfill burial is unacceptable (14).

Hoods should not be used as a means of disposal for volatile chemicals (40, 200).

Disposal by recycling (233, 243) or chemical decontamination (40, 230) should be used when possible.

E. Basic Rules and Procedures for Working with Chemicals

The Chemical Hygiene Plan should require that laboratory workers know and follow its rules and procedures. In addition to the procedures of the sub programs mentioned above, these should include the rules listed below.

1. General Rules

The following should be used for essentially all laboratory work with chemicals:

(a) Accidents and spills - Eye Contact: Promptly flush eyes with water for a prolonged period (15 minutes)

and seek medical attention (33, 172).

Ingestion: This is one route of entry for which treatment depends on the type and amount of chemical involved. Seek medical attention immediately.

Skin Contact: Promptly flush the affected area with water (33, 172, 178) and remove any contaminated clothing (172, 178). If symptoms persist after washing, seek medical attention (33).

Clean-up. Promptly clean up spills, using appropriate protective apparel and equipment and proper disposal (24, 33). See pp. 233-237 for specific clean-up recommendations.

(b) Avoidance of "routine" exposure: Develop and encourage safe habits (23); avoid unnecessary exposure to chemicals by any route (23);

Do not smell or taste chemicals (32). Vent apparatus which may discharge toxic chemicals (vacuum pumps, distillation columns, etc.) into local exhaust devices (199).

Inspect gloves (157) and test glove boxes (208) before use.

Do not allow release of toxic substances in cold rooms and warm rooms, since these have contained recirculated atmospheres (209).

(c) Choice of chemicals: Use only those chemicals for which the quality of the available ventilation system is appropriate (13).

(d) Eating, smoking, etc.: Avoid eating, drinking, smoking, gum chewing, or application of cosmetics in areas where laboratory chemicals are present (22, 24, 32, 40); wash hands before conducting these activities (23, 24).

Avoid storage, handling, or consumption of food or beverages in storage areas, refrigerators, glassware or utensils which are also used for laboratory operations (23, 24, 226).

(e) Equipment and glassware: Handle and store laboratory glassware with care to avoid damage; do not use damaged glassware (25). Use extra care with Dewar flasks and other evacuated glass apparatus; shield or wrap them to contain chemicals and fragments should implosion occur (25). Use equipment only for its designed purpose (23, 26).

(f) Exiting: Wash areas of exposed skin well before leaving the laboratory (23).

(g) Horseplay: Avoid practical jokes or other behavior which might confuse, startle or distract another worker (23).

(h) Mouth suction: Do not use mouth suction for pipeting or starting a siphon (23, 32).

(i) Personal apparel: Confine long hair and loose clothing (23, 158). Wear shoes at all times in the

laboratory but do not wear sandals, perforated shoes, or sneakers (158).

(j) Personal housekeeping: Keep the work area clean and uncluttered, with chemicals and equipment being properly labeled and stored; clean up the work area on completion of an operation or at the end of each day (24).

(k) Personal protection: Assure that appropriate eye protection (154-156) is worn by all persons, including visitors, where chemicals are stored or handled (22, 23, 33, 154).

Wear appropriate gloves when the potential for contact with toxic materials exists (157); inspect the gloves before each use, wash them before removal, and replace them periodically (157). (A table of resistance to chemicals of common glove materials is given p. 159).

Use appropriate (164-168) respiratory equipment when air contaminant concentrations are not sufficiently restricted by engineering controls (164-5), inspecting the respirator before use (169).

Use any other protective and emergency apparel and equipment as appropriate (22, 157-162).

Avoid use of contact lenses in the laboratory unless necessary; if they are used, inform supervisor so special precautions can be taken (155).

Remove laboratory coats immediately on significant contamination (161).

(l) Planning: Seek information and advice about hazards (7), plan appropriate protective procedures, and plan positioning of equipment before beginning any new operation (22, 23).

(m) Unattended operations: Leave lights on, place an appropriate sign on the door, and provide for containment of toxic substances in the event of failure of a utility service (such as cooling water) to an unattended operation (27, 128).

(n) Use of hood: Use the hood for operations which might result in release of toxic chemical vapors or dust (198-9).

As a rule of thumb, use a hood or other local ventilation device when working with any appreciably volatile substance with a TLV of less than 50 ppm (13).

Confirm adequate hood performance before use; keep hood closed at all times except when adjustments within the hood are being made (200); keep materials stored in hoods to a minimum and do not allow them to block vents or air flow (200).

Leave the hood "on" when it is not in active use if toxic substances are stored in it or if it is uncertain whether adequate general laboratory ventilation will be maintained when it is "off" (200).

(o) Vigilance: Be alert to unsafe conditions and see that they are corrected when detected (22).

(p) Waste disposal: Assure that the plan for each laboratory operation includes plans and training for waste

disposal (230).

Deposit chemical waste in appropriately labeled receptacles and follow all other waste disposal procedures of the Chemical Hygiene Plan (22, 24).

Do not discharge to the sewer concentrated acids or bases (231); highly toxic, malodorous, or lachrymatory substances (231); or any substances which might interfere with the biological activity of waste water treatment plants, create fire or explosion hazards, cause structural damage or obstruct flow (242).

(q) Working alone: Avoid working alone in a building; do not work alone in a laboratory if the procedures being conducted are hazardous (28).

2. Working with Allergens and Embryotoxins

(a) Allergens (examples: diazomethane, isocyanates, bichromates): Wear suitable gloves to prevent hand contact with allergens or substances of unknown allergenic activity (35).

(b) Embryotoxins (34-5) (examples: organomercurials, lead compounds, formamide): If you are a woman of childbearing age, handle these substances only in a hood whose satisfactory performance has been confirmed, using appropriate protective apparel (especially gloves) to prevent skin contact.

Review each use of these materials with the research supervisor and review continuing uses annually or whenever a procedural change is made.

Store these substances, properly labeled, in an adequately ventilated area in an unbreakable secondary container.

Notify supervisors of all incidents of exposure or spills; consult a qualified physician when appropriate.

3. Work with Chemicals of Moderate Chronic or High Acute Toxicity

Examples: diisopropylfluorophosphate (41), hydrofluoric acid (43), hydrogen cyanide (45).

Supplemental rules to be followed in addition to those mentioned above (Procedure B of "Prudent Practices", pp. 39-41):

(a) Aim: To minimize exposure to these toxic substances by any route using all reasonable precautions (39).

(b) Applicability: These precautions are appropriate for substances with moderate chronic or high acute toxicity used in significant quantities (39).

(c) Location: Use and store these substances only in areas of restricted access with special warning signs (40, 229).

Always use a hood (previously evaluated to confirm adequate performance with a face velocity of at least 60 linear feet per minute) (40) or other containment device for procedures which may result in the

generation of aerosols or vapors containing the substance (39); trap released vapors to revent their discharge with the hood exhaust (40).

(d) Personal protection: Always avoid skin contact by use of gloves and long sleeves (and other protective apparel as appropriate) (39). Always wash hands and arms immediately after working with these materials (40).

(e) Records: Maintain records of the amounts of these materials on hand, amounts used, and the names of the workers involved (40, 229).

(f) Prevention of spills and accidents: Be prepared for accidents and spills (41).

Assure that at least 2 people are present at all times if a compound in use is highly toxic or of unknown toxicity (39).

Store breakable containers of these substances in chemically resistant trays; also work and mount apparatus above such trays or cover work and storage surfaces with removable, absorbent, plastic backed paper (40).

If a major spill occurs outside the hood, evacuate the area; assure that cleanup personnel wear suitable protective apparel and equipment (41).

(g) Waste: Thoroughly decontaminate or incinerate contaminated clothing or shoes (41). If possible, chemically decontaminate by chemical conversion (40).

Store contaminated waste in closed, suitably labeled, impervious containers (for liquids, in glass or plastic bottles half-filled with vermiculite) (40).

4. Work with Chemicals of High Chronic Toxicity

(Examples: dimethylmercury and nickel carbonyl (48), benzo-a-pyrene (51), N-nitrosodiethylamine (54), other human carcinogens or substances with high carcinogenic potency in animals (38).)

Further supplemental rules to be followed, in addition to all these mentioned above, for work with substances of known high chronic toxicity (in quantities above a few milligrams to a few grams, depending on the substance) (47). (Procedure A of "Prudent Practices" pp. 47-50).

(a) Access: Conduct all transfers and work with these substances in a "controlled area": a restricted access hood, glove box, or portion of a lab, designated for use of highly toxic substances, for which all people with access are aware of the substances being used and necessary precautions (48).

(b) Approvals: Prepare a plan for use and disposal of these materials and obtain the approval of the laboratory supervisor (48).

(c) Non-contamination/Decontamination: Protect vacuum pumps against contamination by scrubbers or HEPA filters and vent them into the hood (49). Decontaminate vacuum pumps or other contaminated

equipment, including glassware, in the hood before removing them from the controlled area (49, 50).

Decontaminate the controlled area before normal work is resumed there (50).

(d) Exiting: On leaving a controlled area, remove any protective apparel (placing it in an appropriate, labeled container) and thoroughly wash hands, forearms, face, and neck (49).

(e) Housekeeping: Use a wet mop or a vacuum cleaner equipped with a HEPA filter instead of dry sweeping if the toxic substance was a dry powder (50).

(f) Medical surveillance: If using toxicologically significant quantities of such a substance on a regular basis (e.g., 3 times per week), consult a qualified physician concerning desirability of regular medical surveillance (50).

(g) Records: Keep accurate records of the amounts of these substances stored (229) and used, the dates of use, and names of users (48).

(h) Signs and labels: Assure that the controlled area is conspicuously marked with warning and restricted access signs (49) and that all containers of these substances are appropriately labeled with identity and warning labels (48).

(i) Spills: Assure that contingency plans, equipment, and materials to minimize exposures of people and property in case of accident are available (233-4).

(j) Storage: Store containers of these chemicals only in a ventilated, limited access (48, 227, 229) area in appropriately labeled, unbreakable, chemically resistant, secondary containers (48, 229).

(k) Glove boxes: For a negative pressure glove box, ventilation rate must be at least 2 volume changes/hour and pressure at least 0.5 inches of water (48). For a positive pressure glove box, thoroughly check for leaks before each use (49). In either case, trap the exit gases or filter them through a HEPA filter and then release them into the hood (49).

(l) Waste: Use chemical decontamination whenever possible; ensure that containers of contaminated waste (including washings from contaminated flasks) are transferred from the controlled area in a secondary container under the supervision of authorized personnel (49, 50, 233).

5. Animal Work with Chemicals of High Chronic Toxicity

(a) Access: For large scale studies, special facilities with restricted access are preferable (56).

(b) Administration of the toxic substance: When possible, administer the substance by injection or gavage instead of in the diet. If administration is in the diet, use a caging system under negative pressure or under laminar air flow directed toward HEPA filters (56).

(c) Aerosol suppression: Devise procedures which minimize formation and dispersal of contaminated aerosols, including those from food, urine, and feces (e.g., use HEPA filtered vacuum equipment for

cleaning, moisten contaminated bedding before removal from the cage, mix diets in closed containers in a hood) (55, 56).

(d) Personal protection: When working in the animal room, wear plastic or rubber gloves, fully buttoned laboratory coat or jumpsuit and, if needed because of incomplete suppression of aerosols, other apparel and equipment (shoe and head coverings, respirator) (56).

(e) Waste disposal: Dispose of contaminated animal tissues and excreta by incineration if the available incinerator can convert the contaminant to non-toxic products (238); otherwise, package the waste appropriately for burial in an EPA-approved site (239).

F. Safety Recommendations

The above recommendations from "Prudent Practices" do not include those which are directed primarily toward prevention of physical injury rather than toxic exposure. However, failure of precautions against injury will often have the secondary effect of causing toxic exposures. Therefore, we list below page references for recommendations concerning some of the major categories of safety hazards which also have implications for chemical hygiene:

1. Corrosive agents: (35-6)
2. Electrically powered laboratory apparatus: (179-92)
3. Fires, explosions: (26, 57-74, 162-64, 174-5, 219-20, 226-7)
4. Low temperature procedures: (26, 88)
5. Pressurized and vacuum operations (including use of compressed gas cylinders): (27, 75-101)

G. Safety Data Sheets

Safety data sheets are presented in "Prudent Practices" for the chemicals listed below. (Asterisks denote that comprehensive safety data sheets are provided).

* Acetyl peroxide (105)
* Acrolein (106)
* Acrylonitrile
Ammonia (anhydrous)(91)
* Aniline (109)
* Benzene (110)
* Benzo[a]pyrene (112)
* Bis(chloromethyl) ether (113)
Boron trichloride (91)
Boron trifluoride (92)
Bromine (114)
* Tert-butyl hydroperoxide (148)
* Carbon disulfide (116)
Carbon monoxide (92)
* Carbon tetrachloride (118)
* Chlorine (119)

Chlorine trifluoride (94)
* Chloroform (121)
Chloromethane (93)
* Diethyl ether (122)
Diisopropyl fluorophosphate (41)
* Dimethylformamide (123)
* Dimethyl sulfate (125)
* Dioxane (126)
* Ethylene dibromide (128)
* Fluorine (95)
* Formaldehyde (130)
* Hydrazine and salts (132)
Hydrofluoric acid (43)
Hydrogen bromide (98)
Hydrogen chloride (98)
* Hydrogen cyanide (133)
* Hydrogen sulfide (135)
Mercury and compounds (52)
* Methanol (137)
* Morpholine (138)
* Nickel carbonyl (99)
* Nitrobenzene (139)
Nitrogen dioxide (100)
N-nitrosodiethylamine (54)
* Peracetic acid (141)
* Phenol (142)
* Phosgene (143)
* Pyridine (144)
* Sodium azide (145)
* Sodium cyanide (147)
Sulfur dioxide (101)
* Trichloroethylene (149)
* Vinyl chloride (150)

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APPENDIX I: GUIDELINES FOR SAFE USE AND HANDLING OF NANOMATERIALS

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Guidelines for Safe Use and Handling of Nanomaterials

Purpose:

As the use of nanoparticles in the industrial and academic settings increases, the need for awareness and safety with handling nanoparticles and using nanomaterials is essential in maintaining a safe work environment for our employees. While this field of research is relatively new, the concepts are currently being applied in a variety of applications here on campus. This document seeks to provide guidelines for safe handling and use of nanoparticles and associated technology. Because the field has recently exploded, research on safety and exposure cannot keep up with the expansion so there are some universal precautions and practices that should be followed to ensure the safety of our employees.

Background:

According to National Institute for Occupational Health and Safety (NIOSH), a nanoparticle measures between 1-100nm in size in at least one dimension. Nanotechnology refers to the manipulation of particles in this size range to create new materials, structures, or devices (Centers for Disease Control and Prevention, 2010). Nanomaterials include terms such as nanoparticle, ultrafine particle, carbon nanotubes (single, double, and multiple-walled), engineered nanoparticles, quantum dots, and nanocrystals. Nanotechnology has become a broad category involving many different areas and disciplines such as physics, biology, chemistry, medicine, and engineering (Albrecht, Evans, & Raston, 2006).

Manufactured nanoparticles are usually created in one of two ways, bottom-up and top-down. As their name implies, bottom-up emphasizes the building of the nanomaterial atom by atom. Top-down requires isolation of single atoms from bulk material. This may include using methods such as milling, attrition, quenching, and photolithography (Cao, 2004). Nanomaterial use in the lab may be from creation during experimentation or use of commercially available nano-scaled materials.

There are many unique characteristics of nanoparticles that are different from their micro-sized counterparts or bulk material form (Klaine, 2009). Some of these unique characteristics that can contribute to the hazards of nanomaterials include: charge, reactivity, shape, size, solubility, surface area, surface composition, surface coating, and degree of agglomeration. How nanomaterials are used in the lab may dictate which hazards may be applicable when in use in the laboratory.

Regulation

To date, there are currently no federal regulations specifically addressing nanotechnology or governing the use of nanoparticles. There are also no well-established guidelines governing use internationally. In absence of regulations it is of upmost importance to use good laboratory practice and treat all nanomaterials as if they were toxic.

General guidelines of the Occupational Health and Safety Administration (OSHA) are still applicable with nanomaterials. Under the general duty clause, employees are entitled to a

workspace that "is free from recognizable hazards that are causing or likely to cause death or serious harm to employees (OSHA, 1970).

Exposure Routes

Exposure may occur at various stages when working with nanomaterials. Processing, packaging, product recovery, sonication, agitation, cleaning, and maintenance are all viable times when an individual may be exposed. Exposure to nanomaterials may occur through dermal absorption, inhalation, or ingestion. Ingestion is thought to occur from hand-to-mouth contact (Aitken, Creely, & Tran, 2004). Ingestion may occur as a secondary exposure route as particles are cleared through the mucociliary escalator and then swallowed. There is not much in the literature to support ingestion as a viable exposure route.

Dermal absorption may occur through powder handling, packaging, and bagging methods (Aitken, Creely, & Tran, 2004). Dermal absorption may also depend on the solution the nanomaterials are contained within as to skin or glove penetration. Dermal absorption should also be considered when cleaning and maintenance of equipment or the area is necessary.

Exposure through accidental injection may be a route of exposure if working with lab animals. Careful attention should be used if working with animals, sharps, and nanomaterials. Literature on exposure through injection is limited.

The main route of exposure will be through inhalation. Factors such as shape, size, and diameter will determine the fate of nanomaterials once in the respiratory tract. Some particle sizes are small enough to enter and become deposited in the region of the lungs where gas exchange occurs. As recognized in animal studies, mouth breathing will lead to deposition of more nanomaterials in the respiratory tract. Inhalation is of significant importance for those individuals who may have a compromised immune system or suffer from lung conditions or diseases.

Reference Studies

Studies conducted accessing exposure and effects from exposure show mixed results. It is unclear the acute or chronic effects that exposure to nanomaterials may cause. Animal studies show negative effects from exposure but extrapolation can sometimes be difficult and dosing in animals is higher than humans would experience in days or even weeks.

Some studies have indicated that carbon nanotubes are cytotoxic to human keratinocyte cells, inhibit embryonic brain cells in rats, and induce granulomas in the lungs of mice (Cui, Tian, Ozkan, Wang, & Gao, 2004). The same study by Cao, et al., examined the effect that single walled carbon nanotubes (SWCNTs) had on human HEK293 cells. Results showed SWCNTs inhibited proliferation, decreased cell adhesion, induced apoptosis (dose and time dependent), and caused cells to attach and secrete 20-30 kd proteins that wrapped and formed nodular structures that would eventually kill the cell (2004).

Another study looking at carbon nanotubes, reported asbestos-like symptoms in mice when exposed to the mesothelial cavity, from particles ranging from 20-100 nm in length and 20 nm wide. Formation of granulomas and inflammation was also noted in the study (Polland, Duffin, Kinloch, Maynard, Wallace, Seaton, Stone, Brown, MacNee, & Donaldson, 2008). These particles

are also thought to be more hazardous than asbestos because of metal impurities that are often in the nanotubes (Ju-Nam & Lead, 2008).

An in vitro study was conducted by AshaRani et al., using human glioblastoma cells. The human cells were treated with silver nanoparticles to determine the toxicity to the cell. Their findings reported mitochondrial dysfunction, DNA damage, and chromosomal aberrations. Some of the cells did undergo DNA repair, but others resulted in cell death. Their findings concluded that use of silver nanoparticles may cause cytotoxicity, genotoxicity, and antiproliferative properties, which could lead to carcinogenesis (AshaRani, Low Kah Mun, Hande, & Valiyaveettil, 2009). A study by Sung et al., examined the long term effects from exposure to silver nanoparticles in rats. The study doesn't mimic actual silver nanoparticle concentrations; it does accurately report a chronic duration study of 90 days for varying concentrations of particles. Their results showed that lung function (tidal volume, minute volume, and peak inspiration flow) all decreased after exposure. Along with the decrease in lung function, lesions were observed along with inflammation in the lungs and from biomarkers. The inflammation resulted in a 16% decrease in overall lung function at the end of the 90-day test period in the rats (2008).

A study by Semmler et al., reported that ultrafine particles of iridium, 15nm in size, were retained in the lungs of rats and cleared out through the mucociliary elevator to be excreted through the feces. This is the same mechanism as larger micro-sized particles. There was a very small fraction (0.002-0.006) that did make it to secondary organs, but they did not accumulate and were cleared after one week (Semmler, Seitz, Erbe, Mayer, Heyder, Oberdörster, & Kreyling, 2004).

Effects from exposure to nanomaterials in humans still remain unclear. Animal studies confirm adverse effects so protection the protection from exposure is warranted. These studies serve as a good indicator of the possible damage from exposure; good laboratory practices are essential to protect individuals from unknown effects.

Working with Nanomaterials

Prior to working with nanomaterials, material safety data sheets should be consulted for hazards associated with the materials. The experiment standard operating procedure (SOP) should also be examined to determine where exposure to nanomaterials may occur. Environmental Health & Safety (EHS) recommends consulting with lab safety and environmental management before experimentation or work with nanomaterials begins. Nanomaterials should only be used in spaces designated as laboratory space because of HVAC design to prevent re-circulation in the building in case of a release.

Cleaning and maintenance to equipment and areas may be another source of exposure to nanomaterials. Special precautions should be taken to avoid creating aerosols when cleaning. Areas should be cleaned using wet wiping techniques; cleaning dry areas is discouraged. The contaminated area or equipment may also be vacuumed using specially designed HEPA vacuum.

Engineering Controls

Engineering controls is the first and most dependable line of defense against hazards that may be associated with the use of nanomaterials. In a study by Lee, et al., reported most workplaces well equipped with proper ventilation and clean rooms show evidence that conventional engineering

controls work for exposure control (2010). Under this premise EHS requires work with nanomaterials to be performed in a chemical fume hood. This will capture any aerosols or particle dusts created with working with nanomaterials. When working in the fume hood, the sash height should be minimized to ensure good face velocity. Other acceptable manufacturing controls include the use of HEPA filters, glove boxes, and good ventilation (Greaves-Holmes, 2009). HEPA filters are effective in filtering out small particle sizes.

Administrative Controls

Doors at entrances of the labs and to office spaces should remain always remain closed when working with nanomaterials or cleaning the area or equipment. As will all chemical laboratories, no food or drink is permitted in the laboratory. Use of application of lotions or cosmetics may increase an individual's chances of exposure in the laboratory. Spill procedures specific to experimentation should be available in the laboratory. Under no circumstances should personal protective equipment (PPE) worn in a lab working with nanomaterials be worn outside the lab. This may lead to contamination of clean areas outside the lab through residual particles on lab coats or gloves.

Personal Protective Equipment

After engineering and administrative controls, personal protective equipment is the last line of defense in protecting an employee from exposure. The following is a list of PPE that should be worn at all times in a laboratory using nanoparticles: safety goggles/glasses, lab coat (preferably with cuffs), and gloves. Glove determination may vary depending on other chemical hazards associated with chemical experimentation. Double-gloving is encouraged. Once gloves are removed, employees should thoroughly wash hands with soap and water. Safety glasses/goggles are required in the laboratory upon entering the lab space. Additional protection such as a face shield may be necessary if there is a risk of aerosols when working with nanomaterials. Lab coats with cuffs are recommended to reduce skin exposure when working. As mentioned above, lab coats should not be worn outside of the laboratory. As with all laboratories, appropriate clothing such as pants and close-toed shoes should be worn when in the lab.

Some applications and uses of nanomaterials may require respiratory protection. Acceptable respiratory protection may include a N95 or N99 mask, full/half face respirator with appropriate cartridges, or a powered air purifying respirator. Fit testing should be performed by EHS prior to use to ensure proper fitting and training of the employee on respirator use.

Waste Accumulation and Disposal Guidelines

All wastes/products accumulated while using nanomaterials should be collected and held for disposal by environmental management. Wastes should be stored in a leak-proof container with a lid. These containers should remain closed when not actively adding waste. Pickup of materials may be arranged by contacting the EHS office or scheduling a pickup through the EHS website.

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