HOWARD UNIVERSITY

HOWARD UNIVERSITY LABORATORY ENVIRONMENTAL HEALTH & SAFETY MANUAL

ENVIRONMENT HEALTH AND SAFETY

Office of Regulatory Research Compliance

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LIST OF ABBREVIATIONS AND ACRONYMS

ACGIH	American Conference of Governmental Industrial Hygienists
AIHA	American Industrial Hygiene Association
ANSI	American National Standards Institute
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
BBP	bloodborne pathogen
BSL	biosafety levels
BSC	Biological safety cabinets
CDC	Centers for Disease Control and Prevention
CFATS	Chemical Facility Anti-Terrorism Standard
CFR	Code of Federal Regulations
CHO	Chemical Hygiene Officer
CHP	Chemical Hygiene Plan
DHS	U.S. Department of Homeland Security
DOT	U.S. Department of Transportation
EH&S	Environmental Health and Safety
EPA	U.S. Environmental Protection Agency
FDA	Food and Drug Administration
HAZCOM	Hazard Communication
HEPA	high efficiency particulate air
HVAC	heating, ventilating, and air-conditioning
IACUC	Institutional Animal Care and Use Committee
IBC	Institutional Biosafety Committee
LD_{50}	lethal dose
LMP	Laboratory Management Program
mg/kg	milligrams per kilogram
SDS	safety data sheet
NIH	National Institutes of Health
NFPA	National Fire Protection Association
OSHA	Occupational Safety and Health Administration
PEL	permissible exposure limit
PHA	process hazard analysis
PHS	U.S. Public Health Service
PI	principal investigators
PPE	personal protective equipment
ppm	parts per million
SAA	Satellite Accumulation Area
SOP	standard operating procedure
STEL	short-term exposure limit
TLV	threshold limit value
USDA	U.S. Department of Agriculture
°F	degrees Fahrenheit

1.0 OVERVIEW

1.1 OVERVIEW

Howard University prepared this Laboratory Environmental Health and Safety Manual to ensure a safe working environment through safe work practices and procedures in laboratories. It is the policy of Howard University (the University) not only to adhere to the local, state and federal regulations but also to Standards of Care and Best Management Practices to provide a safe environment in the laboratories.

1.2 PURPOSE

The purpose of this program is to provide methods to ensure safety in the laboratories located at the University. The program will cover how to minimize or eliminate risk associated with chemical, hazardous, biological and radioactive materials used in the laboratories, electrical hazards and mechanical hazards. It will provided guidelines for staff to ensure a safe environment in their laboratory settings.

1.3 ROLES AND RESPONSIBILITIES

It is the goal of the University to promote and maintain a safe, healthful, and environmentally responsible workplace. Specific responsibilities include:

- Ensuring the adequacy of technical and financial resources to conduct compliance programs in accordance with the University standards and regulatory requirements.
- Identifying personnel affected by specific compliance requirements.
- Communicating compliance program requirements to administration and faculty.
- Securing faculty and administration input for the development and implementations of compliance management programs.
- Communicating, periodically, compliance program status to the University community, including program objectives, results, and effectiveness

1.3.1 Departments

Each department is responsible for supporting and promoting safe and compliant work practices in the laboratory. Department faculty and administration are responsible for facilitating the implementation of the manual within each department.

Department Chairs will appoint chemical hygiene coordinators who work with the Chemical Hygiene Officer (CHO) i.e., the Director of Environmental Health and Safety (EH&S) for ensuring that all work performed within their department complies with applicable health, safety, and environmental requirements. The department chairs may implement this responsibility through delegation to principal investigators (PIs), other faculty, department administration, or other departmental staff deemed appropriate. The duties of the Department Chairs include:

- Collaborating with the administration, EH&S and others to identify effective means to implement this manual in the laboratory.
- Providing feedback to administration regarding compliance status.
- Ensuring that personnel receive required training, to implement the manual effectively.
- Coordinating and facilitating exchange of information regarding chemical hygiene issues with research and teaching community.
- Facilitating compliance with the manual requirements.
- Ensuring compliance responsibilities are assigned and implemented for all areas and operations in the Department. These responsibilities include training, recordkeeping, reporting, program evaluation, and plan revision.
- Communicating EH&S programs to the laboratories, PIs, and their appointed Safety Coordinators.
- Serving as the primary liaison for EH&S Department.
- Monitoring EH&S compliance within their department.

1.3.2 Chemical Hygiene Officer

The CHO, the director of EH&S is critical to the effective implementation of the Laboratory Safety Management Program. The CHO, working with the PI and the department chemical

hygiene coordinator is responsible for the adaption and implementation of this program in his or her laboratory, thus maintaining a safe work environment and ensuring compliance with regulatory requirements. The duties of the CHO include ensuring that:

- Appropriate training is provided to new and current laboratory personnel and is properly documented.
- Workers know and follow established safe work procedures and emergency procedures.
- Safety equipment and engineering controls are utilized.
- Appropriate personal protective equipment is utilized.
- Laboratory practices and safety and control equipment inspections are routinely conducted and properly documented.
- Copies of the up-to-date manual and chemical hazard reference materials (e.g., Safety Data Sheets [SDSs]) are available to laboratory personnel.
- Procedures for new or particularly hazardous substances or operations are coordinated with input from the CHO and the University EH&S Office.
- Accidents and other potential exposure conditions are reported to the CHO and Howard University EH&S Office for further investigation.
- Recommended actions are taken to correct any unsafe condition.

1.3.3 Principal Investigators (PIs)

Each PI plays a critical role in the implementation of this program. The PI has primary responsibility for chemical hygiene and EH&S compliance in his or her laboratory. These responsibilities include ensuring that:

- Laboratory personnel have adequate knowledge and information to recognize and control chemical hazards in the laboratory.
- Hazardous operations are defined and safe practices and protective equipment are designated and provided.
- Safe work practices, personal protective equipment and engineering controls are used to reduce the potential for exposure to hazardous chemicals.

- Laboratory personnel are informed of the potential hazards of the chemicals they use and are trained in safe laboratory practices, controls, and emergency procedures.
- Laboratory personnel are informed of the signs and symptoms associated with exposures to hazardous chemicals used in their laboratory.
- Chemical waste is managed properly.
- Action is taken to correct work practices and conditions that may result in the release of hazardous chemicals.
- He or she grants approval, where required, prior to the use of particularly hazardous substances in the laboratory (see section 2.10).
- Laboratory operations are supervised to ensure that the manual is being followed.
- Compliance with the manual is maintained and documented.

1.3.4 Laboratory Personnel

Laboratory personnel are responsible for:

- Participating in laboratory safety training sessions.
- Being aware of the hazards of the chemicals they are working around or with, and safe storage, handling, and disposal procedures.
- Planning and conducting each operation or experiment in accordance with established chemical hygiene procedures.
- Using appropriate safe work practices, personal protective equipment, and engineering controls at all times.
- Reporting unsafe conditions to their supervisor or department health and safety coordinator

Laboratory personnel and PIs share responsibility for chemical safety in their laboratory, as well as informing visitors entering their laboratory of the potential hazards and safety precautions to be taken.

1.3.5 Environmental Health and Safety Office

The primary responsibility of the University EH&S Office staff is to provide technical support and guidance to laboratory personnel for the development and management of EH&S programs. The University EH&S Office is responsible for reviewing and updating the common (non-laboratory specific) portions of the manual on an annual basis and distributing any required changes to the appropriate University personnel. The University EH&S Office offers the following services relating to chemical hygiene:

- Development and evaluation of safety procedures
- Laboratory inspections and audits
- Fume hood evaluation and inspection
- Training and information dissemination
- Hazardous waste disposal
- Hazard and exposure assessments
- Accident investigation
- Emergency assistance

1.4 TRAINING REQUIREMENTS

The CHO or the chemical hygiene coordinator shall provide information and training concerning the handling of hazardous materials in the laboratory. The University EH&S Office staff is available to assist in developing and implementing training procedures and policies.

Employees shall be informed of the presence of hazardous chemicals when assigned to a work area and prior to new exposure situations. This information must include the following:

1. Contents of the Occupational Safety and Health Administration (OSHA) Laboratory Standard, Title 29 Code of Federal Regulations Section 1910.1450.
2. Applicable details and location of the manual.
3. Emergency and personal protective equipment training.
4. Physical and chemical properties of hazardous substances used in the workplace.
5. Proper handling of hazardous chemicals to minimize exposure.

6. Signs and symptoms of exposure associated with hazardous chemicals used in the workplace.
7. Availability of reference material, including SDSs.

Training should be provided immediately for new employees in the affected work area and annually thereafter for all personnel. The name of each person trained shall be recorded together with the training contents, date, and the trainer.

It is the responsibility of the Department and the PI to assure that all staff members attend the required training sessions. It is the Department's responsibility to alert the University EH&S Office and the CHO of a new employee. Further, if English is not the primary language spoken by a staff member, the Department should ensure that an interpreter accompanies the non-English speaking staff.

1.5 GENERAL LABORATORY PRACTICES

1.5.1 Food and Drink

Food and drink are not permitted in the laboratory at any time. In addition, laboratory members should never smoke, eat, drink, chew gum, apply cosmetics or lip balm or handle contact lenses in the laboratory.

Food used in research (e.g., dry milk, cornmeal, oil, sugar) should be labeled "For Research Use Only."

Alternatives for Food and Drink Storage include:

- Food storage areas (shelving or cubbies) by the outside main entrance to the laboratory areas
- Designating lounge areas for food and drink consumption
- Designated areas within kitchenettes for laboratory food and drink storage

No food and drink in laboratories or adjacent offices will mitigate potential ingestion risk and assure compliance with regulations.

1.5.2 Cell Phone Usage

Cell phone usage in the laboratory should be limited and restricted to emergency use only. Cell phones are difficult to decontaminate if they come in contact with hazardous materials in the laboratory. Land lines designated for usage within the laboratory setting for laboratory personnel will minimize any potential for transfer or exposure.

1.5.3 Restricted Access

Access to laboratories where hazards are present should be limited to researchers or personnel trained on the hazards present in that work area. Visitors to the area must be accompanied by a laboratory member who is familiar with the area and trained in emergency response procedures relating that laboratory. Areas where highly hazardous materials are located should be demarcated and access should not be permitted to visitors or those less familiar with the hazard present.

2.0 CHEMICAL SAFETY

2.1 BACKGROUND

Chemical safety is an integral part of a Laboratory Environmental Health and Safety program. This section will outline regulatory requirements, risk and controls associated with chemical usage and ways to minimize potential chemical risks.

2.2 REGULATIONS

It is the policy of the University to provide a safe and healthy workplace in compliance with the Occupational Safety and Health Act of 1970 and with the following regulations:

- OSHA 29 CFR 1910.1450, *Occupational Exposure to Hazardous Chemicals in Laboratories*
- OSHA 29 CFR 1910.1200, *Hazard Communication*
- OSHA Chemical Specific Policies, 29 CFR 1910 Subpart Z*, Toxic and Hazardous Substances.*
- International Air Transport Association and Dangerous Goods Regulations
- U.S. Environmental Protection Agency (EPA) 40 CFR 260 – 272, *Hazardous Waste Management*
- U.S. Department of Transportation (DOT) 49 CFR 172, Subparts H and I, *Hazardous Materials: Security Requirements for Offerors and Transporters of Hazardous Materials*
- U.S. Department of Homeland Security (DHS) 6 CFR 27, *Chemical Facilities Anti-Terrorism Standards* (CFATS)

The full OSHA standard can be found on the following link:
http://www.osha.gov/comp-links.html.

2.3 LABORATORY SAFETY COMMITTEE

Safety Committees are a critical component in creating a healthy and safe work environment at University. There are numerous local, state and federal regulatory issues that must be addressed regularly and the committee structure will allow the University to

distribute changes in regulatory requirements and to obtain compliance with regulatory requirements campus-wide with minimal interruption to ongoing research.

One representative from each Department at the University is required to attend each meeting, unless it is specified as optional. The function of this committee will be to serve as the primary link between the research community and the Howard University facility management group, including the EH&S office.

The safety committee meets on a quarterly basis. The meetings are used to provide updates on health and safety policies/procedures at the University and any facility related changes or concerns. Committee members serve as primary contact for EH&S issue and assist in the completion of corrective actions required as a result of inspections by the University EH&S and outside regulatory agents. Departments are also expected to create their own safety committee that will meet at least six times per year.

2.4 RISK ASSESSMENT

A risk assessment should be performed prior to the start of any new project or prior to beginning work with any new process or material that may pose a risk to the health and safety of the laboratory workers. The risk assessment should include hazard identification and an analysis of the probability that workers are exposed to the hazard(s) identified. Once this is completed, recommendations for work practice, engineering controls and proper training must be evaluated and established.

2.5 CONTROL BANDING

Control banding is a generic technique that determines a control measure (e.g., dilution ventilation, engineering controls, containment) based on a range or “band” of hazards (such as skin/eye irritant, very toxic, carcinogenic) and exposures (small, medium, large). The principle of control banding was first applied to dangerous chemicals, chemical mixtures, and fumes. The control banding process emphasizes the controls needed to prevent hazardous substances from causing harm to people at work. The greater the potential for harm, the greater the degree of control needed to manage the situation and make the risk “acceptable.”

Source: http://www.cdc.gov/niosh/topics/ctrlbanding/

Materials are first placed into a "hazard band." Factors used to decide which band a product belongs to include:

- Toxicity of the material (how "poisonous" a material is)
- Ease of exposure (e.g., how easy it is for the material to get into a worker's body such as how fine (dusty) or volatile a product is)
- Type of work process being used (e.g., grinding vs. transferring)
- Duration of exposure (amount of time doing the task)
- Quantity of material used in task (small vs. large amounts)

In the example below, the bands represent levels of control: band 1 is low control, while band 4 is the highest amount of control. These bands are based on increased toxicity of the products being used. For example, a skin irritant that is only used in tiny amounts would require less stringent controls than a cancer-causing chemical.

Band No.	Hazard Group	Control
1	Skin and/or eye irritant	Use good industrial hygiene practice and general ventilation.
2	Harmful on single exposure	Use local exhaust ventilation.
3	Severely irritating and/or corrosive	Enclose the process.
4	Very toxic on single exposure; reproductive hazard; sensitizer	Seek expert advice.

Another example is a decision matrix for control selection. Note in this example:

- High ease of exposure AND high health hazard (i.e., high risk) = Stringent control (isolation)
- Medium ease of exposure AND medium health hazard (i.e., medium risk) = Engineering controls (often includes ventilation requirements)
- Low ease of exposure AND low health hazard (i.e., low risk) = Dilution ventilation (least stringent controls)

Health Hazard		High	Medium	Low
Ease of Exposure	High	HIGH Isolation	MEDIUM Engineering Controls	MEDIUM Engineering Controls
	Medium	HIGH Isolation	MEDIUM Engineering Controls	LOW Dilution Ventilation
	Low	MEDIUM Engineering Controls	MEDIUM Engineering Controls	LOW Dilution Ventilation

Source: Sullivan E and Malik O. 2007. Control Banding: Pharmaceutical Caterpillar to Mainstream IH Butterfly. American Industrial Hygiene Association *Diplomate* Article.

2.6 LABORATORY DESIGN

The primary purpose of these design criteria is to establish minimum design requirements for laboratories to provide a safe work environment and prevent undesirable exposures to chemical contaminants among students, faculty, and staff in laboratories.

These design criteria are minimum design standards required for all new construction and renovation projects involving laboratory furniture and fume hoods in Howard facilities. Individual institutions may have more stringent requirements.

Standard References:

- National Fire Protection Association (NFPA) 45, Standard on Fire Protection for Laboratories Using Chemicals
- NFPA 30, Flammable and Combustible Liquids Code
- NFPA 70, National Electric Code
- American National Standards Institute/American Industrial Hygiene Association (ANSI/AIHA) Z9.5, Standard for Laboratory Ventilation
- ANSI/AIHA Z358.1, Standard for Emergency Eyewash and Shower Equipment
- American Society for Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) Standard 55, Thermal Environment Conditions for Human Occupancy
- ASHRAE 110-R, Method of Testing the Performance of Laboratory Hoods

- OSHA 29 CFR 1910.1450, Occupational Exposure to Hazardous Chemicals in Laboratories

New laboratory construction and renovation projects require a system test and balance report to verify proper heating, ventilating, and air-conditioning (HVAC) system and fume hood operation *before* the building or area will be accepted, or occupied, by the institution.

Fume hoods shall not be installed or used primarily for chemical storage. Laboratories where potentially hazardous chemicals or agents are used shall have negative air pressurization relative to surrounding space, and HVAC systems shall be designed to provide 6-10 air changes per hour, depending on use of laboratory space.

In addition, chemical storage cabinets (e.g., flammable, corrosive, acid, caustic) will be used to segregate chemicals and to provide additional protection in the case of an emergency.

2.7 STORAGE REQUIREMENTS

Chemicals must be stored in a manner suited for each chemical's properties. All chemicals have specific properties that may make them incompatible with other chemicals or materials. This section outlines several different types of chemicals and the storage requirements associated with each:

1. Acids
2. Bases
3. Flammables
4. Oxidizers
5. Water Reactives
6. Pyrophorics
7. Peroxide Forming Chemicals
8. Toxic Chemicals
9. Carcinogens
10. Teratogens

The lists below are not all inclusive, but include many of the most-commonly used materials in research laboratories.

2.7.1 Acids

- Store on low shelves or in acid cabinets.

- Segregate oxidizing acids from organic acids as well as flammable or combustible materials (see lists below).
- Use bottle carriers for transporting acid bottles.
- Have spill control materials available which will absorb and neutralize an acid spill.

Strong Oxidizing Acids—nitric acid, sulfuric acid, chromic acid, perchloric acid, hydrobromic acid

Organic Acids—acetic acid, acetic anhydride, phenol, trichloroacetic acid, trifluoroacetic acid

Other Common Acids—hydrochloric acid, phosphoric acid, formic acid, maleic acid, phosphotungstic acid

2.7.2 Bases

- Store bases on low shelves or in designated caustics cabinets.
- Segregate bases from acids.
- Have spill control materials available which will absorb and neutralize a base spill.

Common Bases—ammonium hydroxide, calcium hydroxide, potassium hydroxide, sodium hydroxide, bicarbonate salts (potassium bicarbonate, sodium bicarbonate, etc.), carbonate salts (calcium carbonate, sodium carbonate, etc.)

2.7.3 Flammables

- Store volumes greater than one gallon (four liters) in approved safety cans.
- Store in flammable storage cabinets.
- Keep away from heat and ignition sources (burners, heat-producing equipment, sunny windows, etc.)
- Keep firefighting equipment such as extinguishers accessible and unobstructed.
- Have flammable spill materials available. Activated charcoal absorbent is recommended.
- If flammables must be kept cold, use only a lab-safe refrigerator or freezer (electrical components mounted on the outside) or keep flammables on ice for as long as they are needed cold.

- Never store flammables in cold rooms. Most cold rooms are not sprinklered and all have recirculating air, which can allow dangerous levels of ignitable vapors to build up.

Flammable Solids—benzoyl peroxide, picric acid

Flammable Gases—acetylene, ammonia, butane, carbon monoxide, ethane, ethylene oxide, formaldehyde, hydrogen, hydrogen sulfide, methane, propane, propylene

Flammable Liguids—acetaldehyde, acetone, acetyl chloride, alcohols, benzene, butanol, p-dioxane, ethanol, ethyl acetate, ethylamine, ethyl benzene, ethyl ether, ethyl formate, furans, gasoline, hexane, hydrazine, isopentane, isopropyl ether, methanol, methyl acrylate, 2-methylbutane, methyl butyl ketone, methyl ethyl ketone, methyl methacrylate, morpholine, naphtha solvents, octane, piperidine, propanol, pyridine, Sigmacote, styrene, TEMED, tetrahydrofuran, toluene, turpentine, vinyl acetate, xylene

2.7.4 Oxidizers

- Store in a cool, dry place.
- Keep away from flammable and combustible materials.
- Keep away from reducing agents.
- Dispose of as hazardous waste.

Oxidizing Liquids—bromine, chromic acid, hydrogen peroxide, nitric acid, perchloric acid, sulfuric acid

Oxidizing Solids—ammonium dichromate, ammonium perchlorate, ammonium persulfate, benzoyl peroxide, calcium hypochlorite, salts of chlorates, chromium trioxide, ferric nitrate, salts of iodates, iodine, magnesium perchlorate, manganese dioxide, salts of nitrates, periodic acid, salts of peroxides, potassium dichromate, potassium permanganate, potassium persulfate, silver nitrate, sodium chlorite, sodium dichromate, sodium nitrite, sodium perborate

Oxidizing Gases—chlorine, chlorine dioxide, fluorine, nitrogen dioxide, nitrogen oxide, oxygen, ozone

2.7.5 Water Reactive Chemicals

(React strongly with water, yielding flammable or toxic gases or other hazardous condition).

- Store in a cool dry place.
- Do not store on shelves over sinks or water baths or near any other sources of moisture.
- In case of fire, keep water away.
- Dispose of as hazardous waste.

Solids—anhydrous aluminum chloride, ferrous sulfide, lithium*, lithium aluminum hydride, magnesium, maleic anhydride, phosphorus, phosphorus pentachloride, phosphorous pentasulfide, potassium*, sodium*, sodium borohydride

* Lithium, potassium and sodium should be stored under kerosene.

Liquids—acetyl chloride, chlorosulfonic acid, hydrofluoric acid, phosphoryl trichloride, Sigmacote, silicon tetrachloride, stannic chloride, sulfur chloride, sulfuryl chloride, thionyl chloride, titanium tetrachloride, triethylaluminum

2.7.6 Pyrophoric Chemicals

(Ignite spontaneously upon contact with air)

- Must be stored in accordance with manufacturer's recommendations under an inert atmosphere and at the appropriate designated temperature.
- Pyrophorics that are required to be kept cold must be stored in a explosion-proof refrigerator or freezer that is rated for flammable storage.
- In case of fire, a Class D fire extinguisher must be available. Pyrophoric materials are also often water-reactive, keep water away.

Boron	Cobalt*	Iron*	Phosphorus*
Cadmium*	Diborane	Lead*	tert-butyl lithium
Calcium*	Dichloroborane	Manganese*	Titanium*
Chromium*	2-Furaldehyde	Nickel*	Zinc*

* Finely divided metals form a pyrophoric hazard

2.7.7 Peroxide Forming Chemicals

(Chemicals that, over time, can auto oxidize to form explosive levels of peroxides)

- Store in airtight containers in a dark, cool and dry place.
- Label containers with date received, date opened and date of recommended disposal.
- Dispose of peroxide forming chemicals on or before their expiration date. If no expiration date is listed, contact [add client number] for assistance.
- Peroxide inhibitors, often added to these chemicals, may not be sufficient to control peroxide formation once a container is opened.
- Test periodically for the presence of peroxides. Test strip kits are available through laboratory safety suppliers, contact [add client number] for more information.
- Do not attempt to open containers that are very old, visibly crystallized or cracked.
- Dispose of as hazardous waste.

If testing for peroxides is not done, do not keep chemicals for longer than the following times:

3 Months—Isopropyl ether, potassium metal

12 Months—Acetal, butadiene, cumene, cyclohexane, 4-Dioxane (p-Dioxane), diacetalyn, dicyclopentadiene, ethyl ether, methyl butyl dimethyl ether, tetrahydrofuran, vinyl acetate, vinyl chloride, vinyl ethers, vinyl pyridine

2.7.8 Carcinogens

(Chemicals proven or suspected to cause cancer in humans)

- Label all containers ‘Carcinogen’ or ‘Cancer Suspect Agent’.
- Take proper precautions to avoid exposures.
- Dispose of as hazardous waste.

OSHA Subpart Z lists the following compounds as carcinogens.

4-Nitrobiphenyl	bis-Chloromethyl ether	beta-Propiolactone
alpha-Naphthylamine	beta-Naphthylamine	2-Acetylaminofluorene
methyl chloromethyl ether	Benzidine	N-Nitrosodimethylamine

3,3'-Dichlorobenzidine (and its salts)	4-Aminodiphenyl	4-Dimethylaminoazo-benzene
	Ethyleneimine	

2.7.9 Teratogens

(Chemicals known or suspected to cause reproductive harm including the potential to disturb the development of the embryo or fetus or cause birth defects)

- Label all containers ‘Teratogen’ or ‘Reproductive Toxin’.
- Take proper precautions to avoid exposures.
- Dispose of as hazardous waste.

Aniline	Carbon monoxide	Lead	Radioactive substances
Benzene	Carbon tetrachloride	Mercury	Toluene
Carbon disulfide	Chloroform	Phosphorous	Turpentine

2.8 CHEMICAL HYGIENE PLAN

2.8.1 Purpose

The following section presents the Chemical Hygiene Plan (CHP) required by the above mentioned regulations. The purpose of the CHP is to describe proper practices, procedures, equipment, and facilities for employees, students, visitors, or other persons working in each laboratory at the University to protect them from potential health hazards presented by chemicals used in the laboratory workplace and to keep exposures below specified limits. It is the responsibility of administration, research, and supervisory personnel to know and to follow the provisions of this plan. The CHO, or Department Chair, is responsible for developing, implementing, monitoring, and updating the plan annually. Affected departments are all those maintaining laboratories that contain and use hazardous chemicals, as defined by the regulations.

2.8.2 Development, Implementation and Update

The CHO oversees the preparation of the CHP, specifically the standard operating procedures (SOPs) for the laboratory. The CHO is responsible (per OSHA regulation) for

ensuring that the plan meets the requirements set forth in the 29 CFR 1910.1450 and is fully implemented.

The CHO is responsible for ensuring that the CHP is reviewed on an annual basis and updated as necessary to accommodate changes in OSHA standard 29 CFR 1910.1450, departmental procedures, and personnel policy. In addition, the CHO will ensure that the CHP update includes procedures regarding new hazards and new processes as they are introduced.

The CHO will ensure that the CHP and updates are distributed or made available to those affected by the changes.

2.8.3 Employee Exposure Assessment

The University EH&S Office will perform exposure monitoring, when appropriate, in accordance with Paragraph (d) of OSHA 29 CFR 1910.1450 or other applicable OSHA standards. Other qualified consulting service providers may be employed by the University EH&S Office to conduct such monitoring. All monitoring results will be kept on file in the University EH&S Office. A report summarizing the results of the exposure monitoring will be provided to the University EH&S contact for the laboratory and made available to the person who participated in the exposure monitoring.

2.8.3.1 Staff Exposure Determination

- **Initial monitoring** will be performed if there is reason to believe that those exposure levels for a substance could routinely exceed the action level (or permissible exposure limit [PEL] in the absence of an action level).

- **Periodic monitoring** will be performed if the initial monitoring performed discloses employee exposure over the action level (or PEL in the absence of an action level). The employee's institution shall immediately comply with the exposure monitoring provisions of the relevant standard.

- Monitoring may be terminated in accordance with the relevant standard.

- Within 15 working days after the receipt of any monitoring results, the employees will be notified in writing of these results either individually or by posting the results in an appropriate location accessible to employees.

Anyone with a reason to believe that exposure levels for a substance routinely exceed the action level, or PEL in the absence of an action level, may request that the University EH&S Office initiate the monitoring process.

It will be the responsibility of the CHO to ensure that periodic monitoring requirements are satisfied, when necessary.

The University EH&S Office and the CHO will maintain records in accordance with the record-keeping requirements of OSHA 29 CFR 1910.1450.

Individual hospitals shall establish and maintain, for each employee, an accurate record of any measurements taken to monitor employee exposures and any medical consultation and/or examinations including tests or written opinions required by this standard. The individual hospitals shall ensure that such records are kept, transferred, and made available in accordance with OSHA 29 CFR 1910.20.

Records from monitoring done by other qualified services must be maintained by the CHO and the University EH&S Office.

2.8.3.2 Medical Surveillance

Medical consultations/examinations are coordinated for the University staff through the Employee's Occupational/Employee Health Services and the University EH&S Office under the following circumstances:

- Whenever a staff member develops signs or symptoms potentially associated with a hazardous chemical to which the staff member may have been exposed in the laboratory.
- Where exposure monitoring reveals an exposure level routinely above OSHA's action level or permissible exposure limit for an OSHA-regulated substance requiring such medical monitoring and medical surveillance.

- Whenever an event occurs, such as a chemical spill, leak, or explosion that results in the likelihood of a hazardous exposure. First aid issues are handled by the Employee's Occupational/Employee Health Services during business hours or through the Emergency Room during off-hours.

- Whenever a staff member is exposed to blood or visibly bloody fluids by a needle-stick, open cut, or splash to the face.

2.8.3.3 Exposure Reporting

Staff who believe they have had an exposure should contact the CHO or the University EH&S Office for evaluation.

If employees exhibit adverse health effects, they should report immediately to the Employee's Occupational/Employee Health Services or the Emergency Room. The University EH&S Office will evaluate the situation and conduct air sampling, if necessary, to determine actual exposures. The results of all hazard evaluations and any air sampling data will be available to all occupants of the affected areas. The CHO or the University EH&S Office can be contacted directly for information. In addition, the results of any personal air sampling will be given to the individual and kept on file in the Howard University EH&S Office.

2.8.4 Oversight, Annual Review, Recordkeeping, Compliance and Enforcement

The **CHO** is responsible for establishing and maintaining records for employee training, employee and environmental monitoring, and quantity of chemicals stored in the workplace. In practice, the CHO may designate another individual to assist with this work.

The **Principal Investigator** enforces the CHP by making sure that the chemical hygiene rules are known and followed. The CHO advises and assists in this work and helps with documentation.

The **University EH&S Office** will assist with chemical hygiene and housekeeping inspections. When there are significant changes in existing policies or work practices, an inspection will be conducted soon after the new process is implemented.

2.8.5 Identification and Classification of Hazardous Chemicals

All laboratories must submit an inventory of their hazardous chemicals to the Department Chair on an annual basis as part of the Emergency Signage (National Fire Protection Association [NFPA] Diamond) program. Based on these lists, the Howard University EH&S Office provides laboratory contacts with electronic copies of their laboratory's appropriately labeled NFPA Diamonds for placement at entrance doors into the laboratories.

Hazardous chemicals can be classified into various categories (e.g., corrosive, reactive, flammable, toxic, etc.) and are labeled on the primary container as such. The definitions associated with these categories can be found at the following link:
http://www.osha.gov/SLTC/laboratories/index.html

Alternate means of classifying and identifying hazardous chemicals include the following:

- Lists of known or suspect human carcinogens, prepared by the International Agency for Research on Cancer and the National Toxicology Program, are available through the National Toxicology Program's website:
  http://ntp.niehs.nih.gov/?objectid=72016262-BDB7-CEBA-FA60E922B18C2540

- SDSs are available by contacting the manufacturer. Laboratories should maintain a complete file of SDSs for chemicals used in the area. Each person working in the laboratory must be familiar with the SDSs for chemicals used in the area prior to working in the area.

- When the human or animal median lethal dose (LD_{50}) for any given substance is less than 50 milligrams per kilogram (mg/kg) or if the PEL is less than 10 parts per million (ppm), and if the substance is not on the list inthen the CHO and PI or Department Administrator or designee will have to develop a specific standard operating procedure for this chemical.

- Manufacturers and manufacturers' associations have valuable information. See for a list of Chemical Information Resources.

2.8.6 Selection of Required Control Methods and Authority for Chemical Use

SDSs for many chemicals used in the laboratories indicate recommended limits (e.g., threshold limit value or TLV), OSHA-mandated limits (e.g., PEL, short-term exposure limit, and action limit), or both, as exposure guidelines.

When such limits are stated, they will be used in the laboratories by the CHO and the University EH&S Office staff to assist in determining the safety precautions and control measures necessary when handling toxic materials.

A chemical fume hood certified by the University EH&S Office must be used when the following occurs:

- When working with a compound that has a reported TLV or PEL less than 50 ppm.
- If the LD_{50} is less than 500 mg/kg or the median inhalation dose, LC_{50}, is less than 200 ppm.[1]
- When working with or handling toxic or malodorous materials (e.g., 2-mercaptoethanol) with moderate or high vapor pressure.

2.8.7 Special Provisions for Particularly Hazardous Substances (Carcinogens, Reproductive Toxins, and Acutely and Extremely Toxic Chemicals)

The procedures described in this section must be followed when performing laboratory work with greater than 10 milligrams (mg) of any carcinogen, reproductive toxin, substance with a high degree of acute toxicity, or chemical whose toxic properties are unknown.

These substances must be handled, used and stored only in designated areas of restricted access. Appropriate areas include chemical fume hoods, glove boxes, designated portions of a laboratory, or an entire laboratory if it is specifically dedicated for that purpose.[2] A designated area must be clearly posted with signs warning that a specific, extremely hazardous material is in use and that only those trained to work with it are

[1] These values should be used if a TLV or PEL is not available for the substance in question.

[2] A designated area may be posted with a removable sign if work with extremely hazardous agents is not continuous in the laboratory.

allowed to enter the area while procedures using it are ongoing. The boundaries of the designated area must be clearly defined.

The smallest amount of a chemical that is required by a procedure should be used, purchased, and stored. Whenever possible, material should be ordered in amounts equal to that required in a given procedure to avoid unnecessary weighing out of the material.

Spill procedures must be developed and posted in the designated area. Staff should be familiar with and have available materials that will inactivate the chemical.

Long-sleeved clothing and gloves known to be impermeable to the material must be worn whenever working in designated areas. Because decontamination of jewelry may be difficult, it is recommended that jewelry not be worn when working in a designated area.

The designated area must be decontaminated when work is completed. Contact the University EH&S Office for more information.

Liquid wastes must be put into screw-top containers that are compatible with the chemical. The container must be labeled with the words, *Hazardous Waste*, the chemical name, the type of hazard (toxic, ignitable, corrosive, or reactive), and dated only when full. Hazardous waste labels are available from the University EH&S Office. Hazardous waste must be removed from the lab within three days after filling the container.

2.8.8 Elimination or Substitution

The first step in evaluating the safety of a new experiment, process, or operation is to investigate the possibility of eliminating hazardous materials or substituting with a less hazardous material.[3] When selecting alternate products, care must be taken that one hazard is not being substituted for another.

[3] As an example, instead of using an organic solvent or chromic acid-based material for washing glassware, one should substitute an aqueous-based detergent. Aromatic compounds (i.e., benzene) and chlorinated hydrocarbons (i.e., methylene chloride) in some experiments should be replaced with aliphatic compounds or non-chlorinated hydrocarbons.

The particular process, experiment, or operation may also be modified to reduce the quantity of the hazardous material(s) necessary or limit the potential emission release rate or exposure time.[4] The use of a secondary containment device, such as a pan, can also be helpful in preventing or minimizing the effects of chemical spills. The University EH&S Office should be consulted for advice at [add client contact information]

2.8.9 Enclosure, Isolation and Regulated Areas

Reducing the potential for exposure to particularly hazardous chemicals is achieved by restricting the use of the material to a designated area equipped with the proper control devices. This designated area can be a glove box, fume hood, bench, or an entire laboratory depending on the manipulations required. Hazardous substances are stored, used, and prepared for disposal only in designated areas. The designated area is identified by signs to alert others of the presence of a particularly hazardous material. For example:

Over balance area:	**CAUTION: ACRYLAMIDE BALANCE**
On glove box:	**CAUTION: AFLATOXIN IN USE**

Radiation signs are available from the Radiation Safety Office at (202) 806-7216 information]. Biohazard signs are available from the Biosafety Officer at (202) 806-9710.

In addition to establishing the physical boundaries that define the designated area, procedures used in a designated area have special provisions. These include storage, use of protective equipment, containment, equipment disposal, and decontamination procedures.

[4] For example, the use of micro scale techniques may be applicable in measuring boiling points of a material. Another example is the substitution of closed systems for open vessels.

2.8.10 General Work Practices and Standard Operating Procedures for Chemicals or Classes of Chemicals

Before developing general work practices and standard operating procedures, it is important to consult the SDS for the chemical. The following are general guidelines for responding to an incident.

2.8.10.1 General Work Practices—Spills

- **Eye Contact:** Eyes should be promptly flushed with water for 15 minutes. Medical help should be sought immediately after flushing.

- **Skin Contact:** Contaminated clothing should be removed as quickly as possible and the affected area flushed with water for 15 minutes. Medical attention should be sought immediately after flushing.

- **Clean up with no injury:** If no one is injured, the cleanup of the spill should begin immediately. For assistance or advice, call EH&S at (202) 806-1033.

- **Clean up with injury:** If someone is injured, that person should seek medical assistance immediately. Clean up should be initiated by someone other than the injured person. For assistance or advice, call EH&S at (202) 806-1033.

2.8.10.2 General Work Practices—Avoidance of Routine Exposure

- Work should be conducted in a chemical fume hood whenever possible.
- Smelling chemicals to determine their identity should be avoided.
- **Never** place your head inside of a chemical fume hood to check on an experiment.
- Inspect gloves before use.[5]
- Release of toxic chemicals (including dry ice) in cold or warm rooms must be avoided, these rooms contain recirculated atmospheres.
- Exhaust of an apparatus (e.g., vacuum pumps) that may discharge toxic chemicals should be vented into a fume hood or filter.
- When transporting hazardous chemicals, use one or more of the following:
  - Carts designed to prevent bottles from spilling;
  - Secondary containment; or

5 Up to 5% of all new and unused gloves have holes or tears in them.

- Bottle carriers.

2.8.10.3 General Work Practices—Choice of Chemicals

- Less toxic substances should be substituted in place of more toxic ones wherever possible.
- Only those amounts necessary for immediate work should be ordered.

2.8.10.4 General Work Practices—Personal Hygiene

- No eating (including chewing gum), drinking, smoking, or applying cosmetics is allowed. The use of contact lenses in the laboratory should be avoided.

- Mouth pipetting of **any** substance is prohibited.

- Hands must always be washed before leaving the laboratory. Solvents must never be used to wash hands.

- Laboratory coats and safety glasses should be worn in the laboratory whenever there is a potential for exposure to infectious, chemical, or radioactive hazards. Appropriate gloves must be worn when handling chemicals. “Effective Use of Gloves.” This equipment should not be worn in cafeterias, bathrooms, and conference areas to avoid cross contamination.

2.8.10.5 General Work Practices—Appropriate Storage of Chemicals

- Incompatible chemicals must be segregated
- Glass bottles must not be stored on high shelves or on the floor.
- Chemicals should be stored in containers with which they are compatible.
- All bottles must be labeled with the correct chemical name in English and using no abbreviations. Bottles should be dated upon receipt and again upon opening.

2.8.10.6 General Work Practices—Procedures for Flammable Chemicals

- General Use and Handling
  - Flammable liquids are defined as those liquids with a flash point of 140 degrees Fahrenheit (°F) or less and having an absolute vapor pressure of not more than 40

pounds per square inch at 100 °F. Some examples commonly found at the University are acetone, methanol, ethanol, ether, and xylene. All flammable liquids should be handled carefully.

- Flammable substances should be handled only in areas free of ignition sources (e.g., away from electric ovens, burner flames, and hot surfaces).
- Flammable substances should never be heated using an open flame. Heating mantles, oil baths, safety hot plates, and steam baths should be used. When heating either by steam bath or hot plate, use a filter or distilling flask as a receiver. Such distillations must be carried out in a fume hood.
- Smoking is not permitted at the University.
- Boiling chips or glass beads are helpful in distilling or evaporating flammable substances to prevent superheating and bumping.
- Ground cylinders or equipment when transferring flammables from one container to another. Contact the EH&S department, if there are questions about proper grounding.

- Storage
  - Bottles of volatile liquids should not be stored near heat sources or in direct sunlight.
  - Quantities of flammable solvents stored in the laboratory should be kept to a minimum. The Fire Department limits storage based on the type of liquid, the floor, where the solvents are stored, and the size of the laboratory (control area). Contact the University EH&S Office at (202) 806-0133 regarding the limit for your control area. Whenever possible, flammable liquids including spray and squeeze bottles should be stored in approved storage cabinets. Flammable liquids must never be stored on the floor.
  - Adequate ventilation must be provided where flammable liquids are used.
  - When flammable liquids are stored in a refrigerator, it must be a *Laboratory-Safe* Refrigerator (as defined in NFPA 45). These are approved for storing flammable liquids and have all electrical equipment mounted on the outside surface of the refrigerator.

- Flammable liquids must not be stored with chemicals that are considered to be incompatible with them (e.g., oxidizers, oxidizing acids, etc.).

2.8.10.7 General Work Practices—Procedures for Reactive Chemicals

Reactive materials include oxidizers, organic peroxides, explosives, air sensitive, shock sensitive, temperature sensitive, and those ranked 3 or 4 for instability by the NFPA. These materials are known as unstable materials. Each laboratory is responsible for disposing of unstable materials prior to them becoming potentially explosive.

For peroxide-forming chemicals (e.g., ethyl and isopropyl alcohol ethers, tetrahydrofuran), containers should be dated upon opening and disposed of as hazardous waste by the expiration date or within six months, whichever is sooner.

All reactive materials must be handled with caution, personal protective equipment must be used, and, where possible, work should be done in a chemical fume hood.

2.8.10.8 General Work Practices—Procedures for Corrosive Chemicals

- Extreme care must be exercised in handling and pouring corrosive materials. This includes: approved gloves, a laboratory coat, and safety glasses.

- Acids and similar chemicals should not be stored above laboratory bench level.

- Corrosive materials should not be heated or handled in large, fragile containers (e.g., four-liter beakers) without providing a secondary containment to catch the contents in case of breakage.

- Porcelain dishes should not be used as cleaning baths.

- Strong alkalis should not be stored next to strong acids.

- Inorganic acids and organic acids should be segregated from each other.

- If strong acids or alkalis come in contact with skin or clothing, affected parts should be washed quickly and thoroughly with large quantities of water. If such materials are

splashed in the eyes, they should be flushed thoroughly with a continuous stream of cold water for at least 15 minutes. In either case, medical attention should be sought immediately.

2.8.10.9 Special Procedures: Work with Formaldehyde

OSHA's formaldehyde standard, *Occupational Exposure to Formaldehyde,* 29 CFR 1910.1048 states that the eight-hour PEL time-weighted average for people working with formaldehyde is 0.75 ppm. The short-term exposure limit (STEL) time-weighted average for 15-minute exposure is 2.0 ppm.

The Hazard Warning for formaldehyde, including labeling requirements, falls under the OSHA *Hazard Communication Standard*. If formaldehyde is to be used by any individual in the laboratory, all staff should be informed of the health hazards of formaldehyde upon initial orientation to the work site.

2.8.11 Personal Protective Equipment

Personal protective equipment (PPE) is designed to prevent personal injury. Examples of PPE include safety glasses or goggles, face shields, safety shields, gloves, rubber aprons, laboratory coats, and protective creams. It is the responsibility of the Department Administrator and/or PI to ensure that laboratory staff is using necessary safety equipment.

The type and level of equipment can be determined with the aid of the CHO and the University EH&S Office. Use of PPE should only be considered after exercising all options for reducing the hazards. If in doubt about the potential danger of an experiment or activity, all available safety devices should be employed. Information on such devices can be obtained from the Howard University EH&S Office upon request.

2.8.11.1 Respirators

Required use of a respirator is the responsibility of the Department Administrator, the PI (or their designee), the CHO, and the University EH&S Office. The Howard University respirator policy must be followed when respiratory protection is required. All staff must follow these elements.

- Less hazardous materials should be substituted for more hazardous materials.

- Laboratory fume hoods or other engineering controls should be employed to control exposure.

- If items 1 and 2 above have been considered but added protection is still deemed necessary, respirator type shall be selected on the basis of type of chemical exposure, level of exposure, and user medical examination.

- Selection of a respirator type must be performed in consultation with the University EH&S Office.
- A medical clearance is required for each employee before a respirator is used routinely. A medical clearance can be obtained through the University's Occupational/Employee Health Services.

- Appropriate fit testing and training shall be performed under the direction of the institution for all negative pressure respirators before use. [Need client information]

- The respirator user must regularly maintain and clean reusable respirators.

- The respirator user must perform a negative and positive pressure check before each use.

2.8.11.2 Eye Protection

At minimum, ANSI-approved safety glasses and/or goggles are required to be worn when working with any hazardous materials, or when there is a risk of splashing, irritating mists, vapors, fumes, or flying projectiles.

Ordinary prescription glasses are **not** designed to provide adequate protection against occupational hazards. Prescription safety glasses are recommended for employees who must routinely wear safety glasses in lieu of fitting safety glasses over their personal glasses.

Safety Goggles

Safety goggles will provide a greater degree of protection than safety glasses by providing a tighter fit against the face. Safety goggles or face shields should be worn whenever there is an elevated risk of a chemical splash or flying projectiles, or when working with volatile substances that irritate the eyes (e.g., chlorine, strong ammonia, irritating dusts).

Face Shield

When working with a corrosive liquid, dispensing liquefied nitrogen, or where otherwise appropriate, a face shield should also be worn to protect the chin, neck, face, and ears. Face shields will supply added protection from flying particles and liquid splash. To gain maximum protection against chemical splash, a face shield should be used in conjunction with safety glasses.

Note: Contact Lenses

Wearing of contact lenses is discouraged when working with hazardous materials. Persons who wear contact lenses are at greater risk for prolonged exposure and potentially permanent eye injury in the event of a chemical splash, since some chemicals can be absorbed into the contact lens and make it harder to remove. Using contaminated fingers to remove contacts in a stressful splash situation represents further exposure risk. If contact lenses are worn when working with hazardous materials, safety glasses (at a minimum) must be worn to protect the eyes, and safety goggles are encouraged.

2.8.11.3 Protective Clothing

The use of protective clothing, including gloves, shall be determined by the University EH&S Office. When working with a potential hazardous material, protective clothing is required.

- Protective clothing is chosen, with the aid of the University EH&S Office, on the basis of the chemical exposure and medical condition of the user.
- Contaminated protective clothing must be disposed of properly.
- Open-toed shoes or sandals shall not be worn in the laboratory.
- Skin should not be exposed when working with hazardous materials.
- Contaminated laboratory coats shall not be worn.

NOTE: Laboratory coats should not be worn in common areas

(Cafeterias, bathrooms, kitchen areas, outside, conference rooms, break rooms, etc.)

2.8.11.4 Protective Gloves

When handling toxic or hazardous chemicals, protective gloves are required. To protect against accidental spills or contamination, workers should refer to glove manufacturers' glove charts to select a glove appropriate for use with the reagent in question. There is no glove currently available that will protect against all chemicals for all types of tasks. If the gloves become contaminated, they should be removed and discarded as hazardous waste as soon as possible.

Staff members must remove at least one glove before leaving the immediate work site to prevent contamination of public areas (e.g., doorknobs, light switches, telephones, etc.).

Latex Alert: Latex (i.e., several protein antigens) has been shown to be a sensitizer. In order to best protect workers from becoming sensitized, powdered latex exam gloves are PROHIBITED in the University laboratories. Powder-free latex gloves may be used where appropriate.

NOTE: Latex gloves do not protect against every hazardous material.

2.8.11.5Other Personal Protective Equipment

Other personal protective equipment shall be used as needed.

Safety shields are recommended for use whenever solvent or vacuum distillations are being run in glass equipment or whenever large glass vessels are subjected to a vacuum. Safety shields should also be used during reactions involving unknown characteristics or that contain toxic or radioactive materials (e.g., high-energy emitters such as ^{125}I or ^{32}P).

2.8.12 Ventilation, Fume Hoods and Proper Operations

Local exhaust ventilation is the primary method used to control inhalation exposures to hazardous substances. Other types of local exhaust include vented enclosures for large

pieces of equipment or chemical storage and snorkel types of exhaust for capturing contaminants near the point of release.

A laboratory fume hood should be used when working with hazardous substances. A properly operating and correctly used fume hood will control the vapors released from volatile liquids, as well as unpropelled dusts and mists.

Do not make any modifications to hoods or ductwork without first calling the University EH&S Office at (202) 806-0133.

A fume hood should not be used for large pieces of equipment unless the fume hood will be dedicated for this use since it will change airflow patterns and render the fume hood unsafe for other uses. It is generally more effective to install a specially designed enclosure for large equipment so that the hood can be used for its intended purpose.
A fume hood should not be used for chemical or other miscellaneous storage, this also restricts airflow. Chemicals should be stored in a sealed (following NFPA 45 requirements) chemical storage cabinet. All freestanding cabinets should have bungs in place and the doors should close properly.

Before you begin using a fume hood, check to see that the hood is labeled appropriately for use with toxic chemicals and has been certified within the last year. If a fume hood requires certification or if you have questions regarding fume hood operation, contact the University EH&S Office at (202) 806-0133.

Some of the basic guidelines for working safely in a chemical fume hood include the following:

1. Work at least six inches behind the sash.
2. If it is necessary to store materials in a fume hood, they should be elevated so that air can pass under them.
3. Never put your head (or face) inside an operating fume hood to check on an experiment.
4. Work with the sash in the lowest position possible. The sash will act as a barrier and provide containment should a problem arise with the reaction.

5. Do not clutter the hood with bottles or equipment. Only materials actively in use should be in the fume hood.
6. Clean the grille along the bottom slot of the back of hood regularly so it does not become clogged with paper and dirt.
7. Do not dismantle or modify the physical structure of the hood or exhaust system in any way without first consulting the University EH&S Office.
8. Report any suspected hood malfunctions to the University EH&S Office. 2.8.13 Housekeeping

It is essential for both safety and efficiency that the facilities be kept neat and orderly. Floors, shelves, and benches should be free from dirt and unnecessary apparatus and tools. Equipment should never obstruct exits, passages, or fire extinguishers, etc.

Care should be exercised when disposing of materials. Flammable or toxic materials should be collected for disposal as hazardous waste and, therefore, should not be placed in the regular waste stream.

General guidelines for good housekeeping include the following:

1. Never block access to emergency equipment, showers, eyewashes, and exits.
2. Label all chemical containers with the identity of the contents and list the appropriate hazards.
3. All work areas should be kept clear of clutter.
4. All aisles, hallways, and stairs must be kept clear.
5. All chemicals should be returned to their proper storage area at the end of the day.
6. Liquid wastes should be kept in spill-proof containers and stored off the floor in an appropriate storage area.
7. ALWAYS BE PREPARED FOR SPILLS. Small spills should be cleaned up promptly using the spill kits located in the laboratory. All clean up materials must be collected for disposal as hazardous waste.

2.8.14 Signs and Labels and Material Safety Data Sheets

2.8.14.1Emergency Signage

The Fire Department requires that each laboratory have appropriate signage to indicate the level of the hazard with respect to the chemicals stored in the laboratory. This signage takes the form of a diamond (NFPA 704 diamond), which is comprised of four smaller diamonds. Each smaller diamond is color-coded to represent a specific hazard classification: blue for health hazards, red for flammability hazards, yellow for reactivity hazards, and white for special classes of hazards. For more information on NFPA diamonds, refer to Appendix A.

Each small diamond contains a number from 0 to 4. A hazard level of 0 on the NFPA diamond represents no hazard while a hazard level of 4 on the NFPA diamond represents the highest hazard in that category. Fires and other emergencies may be dealt with more effectively and safely if the emergency responders are informed of the level of hazards in a specific area. The names and emergency phone numbers of the current Department Administrator or PI responsible for each laboratory area, including shared spaces, should also be posted. Laboratories are responsible for keeping their contact information current.

Signs are inspected annually by the University EH&S Office and are based upon the chemical inventories received from the laboratories. It is extremely important that contact names and chemicals are kept current. The Fire Department may choose not to enter a laboratory if the information provided appears to be out-of-date.

2.8.14.2 Other Signs

1. Radioactive or biohazardous substances used in laboratories require the posting of special signs.
2. *Eye Protection Required* signs are recommended at entrances to laboratories using acids and corrosive chemicals. Safety glasses for visitors must be provided.
3. Signs indicating the location of fire blankets, eyewash units, safety showers, fire extinguishers, and other safety devices are required.

4. Entrances to laboratories, storage areas, and associated facilities must have signs as necessary to warn emergency personnel and custodians of unusual or severe hazards.[6]

2.8.14.3 Chemical Container Labeling

All containers must be labeled with the chemical contents. The labels must be in English and have no abbreviations on them. Chemicals received from outside vendors or from internal stockrooms must have labels indicating the name, along with other physical and chemical data. Toxicity warning signs or symbols should be prominently visible on the labels.

All chemical containers that have been decanted from an original container must be labeled with the chemical name, the primary hazard(s), the name of the responsible person, their PI, and the date. The University EH&S Office can be contacted for further information regarding labels for this purpose.

All chemical waste containers must be labeled with the words *Hazardous Waste*, the full chemical name(s), the type of hazard (i.e., toxic, ignitable, corrosive, or reactive), the responsible person, and the date the container became full. Labels are available from the University EH&S Office .Labeling must be provided for chemicals synthesized in the laboratory or prepared by other processes, such as distillation or extraction. For information about obtaining hazard labels, please contact the University EH&S Office.

Chemicals developed in the laboratory must be assumed to be toxic if no data on toxicity are available. Suitable handling procedures must be prepared and implemented, including training of users in controls necessary to handle a material safely. If the substance is produced for another user outside of the laboratory, a SDS and labels must be prepared and provided to such users in accordance with the OSHA *Hazard Communication* standard 29 CFR 1910.1200.

For information on the labeling of biohazardous materials, as required by the OSHA *Bloodborne Pathogen* standard 29 CFR 1910.1030.,

[6] Examples of severe or unusual hazards that may require signs are unstable chemicals, toxic or carcinogenic materials, water reactive chemicals, and radioactive materials.

2.8.14.4 Safety Data Sheets

SDSs are bulletins prepared by manufacturers to summarize the health and safety information associated with their products. The manufacturer or supplier should provide SDSs for each chemical. A complete file of SDSs should be maintained in the laboratory and must be accessible to any staff member or visiting professional. More information can be obtained from SDS link below:
https://msdsmanagement.msdsonline.com/6455dc57-8e3e-4904-bd68-84e978899bf8/ebinder/?nas=True

The 16 information required by OSHA in SDS in the following order is given below::

1 Identification
2 Hazard(s) identification
3 Composition/information on ingredients
4 First-aid measures
5 Fire-fighting measures
6 Accident release measures
7 Handling and storage
8 Exposure controls/personal protection
9 Physical and chemical properties
10 Stability and reactivity
11 Toxicological information
12 Ecological information
13 Disposal considerations
14 Transport information
15 Regulatory information
16 Other information

A user's guide to SDSs can be found in. Consult with the University EH&S Office to apply this general information to your work situation.

2.8.15 Waste Disposal

Every effort should be made to dispose of hazardous waste in a proper, safe, and efficient manner. It is the responsibility of the individual creating the waste to properly identify and handle waste chemicals within the University facility.

The University EH&S Office maintains a “Main Accumulation Area” for the storage of chemical hazardous wastes transported from the laboratories.

Each Department maintains Satellite Accumulation Areas (SAAs) in the laboratories for the storage of chemical hazardous waste. The following guidelines must be followed at all SAAs.

- Once a waste container has been filled in the laboratory, it must be transported out of the laboratory to the main accumulation area and/or directly off-site through the hazardous waste vendor for disposal within three days.
- Waste chemicals stored in containers of one gallon or larger sizes shall be **break-resistant** whenever possible.
- Waste chemicals stored in breakable containers of one gallon or larger sizes shall be kept in **approved secondary containers**.

  – Break-resistant shall mean a container made of metal, plastic, plastic-coated glass or metal overpacks of glass.

  – An approved secondary container is a bottle carrier made of rubber, metal, or plastic with carrying handle(s) which is of large enough volume to hold the contents of the chemical container. Rubber or plastic should be used for acids/alkalines, and metal, rubber, or plastic for organic solvents.

- Wastes must be packaged and placed in containers in a manner that will allow them to be transported without the danger of spillage, explosion, or hazardous vapors escaping. Wastes that have not been properly packaged and identified will not be accepted for disposal.

2.8.15.1 Unknown Waste Chemicals

Every effort should be made by the Department Administrator or PI to identify unknown waste. It is the responsibility of the department to identify all chemicals. The Department Administrator or PI may need to question laboratory personnel, students, and volunteers, or send a sample to an analytical laboratory, to ascertain the contents of unknown wastes. All charges associated with the identification of an unknown waste will be paid by the laboratory/department. Laboratory personnel must be constantly reminded to identify and label all wastes and project products. If unknown waste has been discovered and cannot be identified, immediately contact the University EH&S Office.

NOTE: Never mark a container "UNKNOWN."

Label unknown waste streams with the words "Pending Analysis."

2.8.15.2 Transportation

All hazardous waste will be collected from the laboratories and transported to the Main Accumulation Area by a representative of the Howard University EH&S office.

2.8.15.3Guidelines for Waste Reduction/Management

Procedures for waste disposal should be prepared **before** beginning a project. Waste must be labeled properly. Each department, group, or researcher must properly identify waste materials prior to disposal; inadvertent mixing of incompatible materials could have serious consequences.

Waste minimization is very important to protect the environment and also to reduce the disposal costs charged to the laboratory. The following suggestions should be considered in an effort to minimize the amount of waste generated by the laboratory.

- Order only and store the amount of material needed for the project or experiment.
- Use only the amount of material that is needed for conclusive results.
- Date containers upon receipt and again upon initial opening.
- Before disposing of unwanted, unopened, or uncontaminated chemicals, check with others at Howard University who may be able to use them using the ChemShare Inventory program.

- On termination of a research project, all unused chemicals to be kept by the laboratory shall be labeled and dated. All chemicals for disposal must be in proper containers and labeled with the words *Hazardous Waste*, the chemical name, type of hazard (toxic, ignitable, corrosive, or reactive), and the date.

2.8.15.4 Types of Chemicals and their Disposal

Regulations prohibit the discharge of most organic solvents into the sewer system. Small amounts of water-soluble, non-flammable materials may be discharged down the drain. The University EH&S Office must be consulted to determine which chemicals can be disposed in this manner.

Table 2.1 Types of Chemicals and Their Disposal

Chemical Class	Disposal
Organic solvents	• Packed in suitable containers that prevent vapors or liquids from escaping. • Tightly cap • Prominently label containers • Disposed as hazardous waste
Mixtures of organic solvents	• If compatible they can be combined in one container • Container must have estimated percentages of each solvent in the mixture.
Ether (di-ethyl) in cans	• Do not move if over a year beyond the expiration date or beyond six months from the date of opening • The Howard University EH&S Office must be contacted immediately.
Acids and alkaline solutions	• Concentrated acids and caustics must be treated as hazardous waste • Store in tightly capped and labeled containers
Inorganic and organic solids	• If in original containers may be sent to the Howard University hazardous waste room.
Mercury	• Contact Howard University EH&S Office to dispose of mercury containing equipment. • Put broken mercury thermometers into a jar or secondary container. • Clean-up materials from a mercury spill may be placed in a container, labeled, and sent to the hazardous waste accumulation area. • Mercury-containing compounds must be disposed through the hazardous waste room.
Cyanide compounds, arsenic, lead, and heavy metal wastes	• Place in bottles or containers • Seal tightly • Label, and place in the hazardous waste accumulation area
Alkali metals (e.g., sodium and potassium)	• Place in a suitable container • Cover with Nujol® (mineral oil) • Label properly, seal and dispose as hazardous waste
Pyrophoric metals (e.g., magnesium, strontium, thorium, zirconium, and other pyrophoric chips and fine powders)	• Place in a metal container • Seal tightly • Label, and send out as hazardous waste
Waste oil (e.g., vacuum pump oil or lubricating oils)	• Collect in one-gallon containers or less • Dispose of as hazardous waste

The University EH&S Office may be consulted if there is any question concerning the toxicity or packaging of any toxic wastes.

2.8.15.5 Other Types of Wastes—Special Procedures Required

- **Compressed gas cylinders** are to be returned to the proper vendor. Some small lecture bottles are of the non-returnable type and become a disposal problem when empty or near empty with a residual amount of gas. When ordering gases in lecture bottle size, be sure to order the gases in a returnable cylinder.

- **Controlled drugs** to be disposed of as waste **must not be sent to the waste accumulation area**. The handling, records, and disposal of controlled drugs are the responsibility of the department and must be conducted within Drug Enforcement Agency regulations.

- **Radioactive material** disposal is handled in accordance with procedures established by Radiation Safety. Contact Radiation Safety Officer at (202) 806-7216.

- **Biological waste and physically dangerous waste (sharps) must be placed in proper containers.** Contact the University EH&S Office at (202) 806-0133 for proper disposal procedures.

- **Polychlorinated biphenyls** found in capacitors, transformers, equipment, and oil is the responsibility of the department. Information on possible disposal contractors can be obtained by calling the University EH&S Office.

2.8.16 Emergency Situations

Emergencies that may occur in a laboratory include fire, explosion, chemical spill or release, or medical or other health threatening accidents. General procedures to be followed in any emergency are the following.

1. Assist person(s) involved. Remove person(s) from exposure to further injury or a life-threatening situation, if it can be done safely.
2. Notify nearby persons who may be affected and call the University EH&S Office to report the emergency and seek assistance.
3. Evacuate the area until help arrives.
4. Wait for emergency responders and assist them in handling the emergency.
5. Assist in the follow-up investigation of the emergency.

For specific emergencies that may occur in the laboratory space (i.e., chemical spills, fire, explosion, etc.), refer to the specific procedures established by the laboratory.

2.8.17 Emergency Equipment

In any emergency, it is critical that all staff members are familiar with the use and location of emergency equipment. These include fire extinguishers, fire alarms, safety showers, and eyewash stations.

All emergency equipment is on a preventive maintenance schedule. Fire alarms are tested periodically and extinguishers are inspected monthly by the building management entity. Safety showers on a quarterly basis and eyewash stations on a monthly basis are tested by the University EH&S Office.

2.9 HAZARD COMMUNICATION

2.9.1 General Information

In order to comply with the OSHA Standard 29 CFR 1910.1200, *Hazard Communication*, the following written Hazard Communication (HAZCOM) Program is established for the University. This program applies to all work operations in this facility where employees may be exposed to hazardous substances during normal working conditions or during an emergency situation. This written program may be obtained from the University EH&S Office at [need contact information]. Under this program employees will be informed of the contents of the OSHA Hazard Communication Standard, the hazardous properties of the chemicals and materials with which they work, the safe handling procedures, and measures to take to protect themselves from these chemicals.

The PIs and Laboratory or Department Administrators are ultimately responsible for ensuring that all applicable provisions and components of the HAZCOM Program are implemented as required within their respective departments. To this end, PIs and Laboratory or Department Administrators are encouraged to designate a person or persons to see to it that each of the program elements are being fully addressed (e.g., labeling, SDSs availability to employees, employee training and information, maintaining

a list of hazardous materials in the laboratory, informing employees of hazardous non-routine tasks, etc.).

The provisions of this program will apply in all situations involving the use of hazardous materials which are not otherwise included within the scope and coverage of the Chemical Hygiene Plan discussed in section 2.8. This HAZCOM Program applies to the laboratory areas within University.

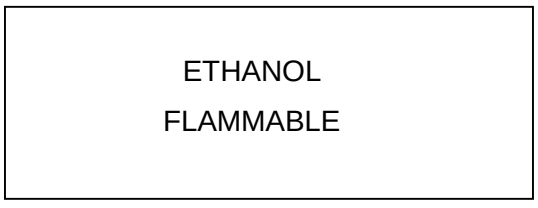
2.9.2 Container Labeling

The laboratory safety contact will verify that all containers of hazardous chemicals received from manufacturers, distributors, or importers are clearly labeled to indicate:

- The identity of the contents. The identity of the contents must match the corresponding SDS.
- Appropriate hazard warnings, including routes of entry into the body and the target organs, if known.
- The name and address of the manufacturers, importer, or responsible party.

The laboratory safety contact will ensure that secondary containers are properly labeled when required. Chemicals that are transferred from a labeled container to a portable container for the immediate use by the person transferring the chemical do not require a label on the portable container. The University policy urges that all containers be labeled in English despite the intended period of use. The person in charge will assure that hazard warning labels on the containers are not removed or defaced unless the hazard is no longer present.

Secondary containers must be labeled with the name of the hazardous chemical (no abbreviations) and the hazard associated with the hazardous chemicals in English. Labels used for secondary containers may be copies of the original manufacturers' labels or a facsimile. The following is an example of a label:



Laboratories with members, who speak other languages, may add the information in the non-English language as long as the information is presented in English as well for Emergency Response purposes.

2.9.3 Safety Data Sheets

The SDS is a detailed information bulletin prepared by the manufacturer or importer of a chemical product or chemical substance. It describes the chemical and physical hazards associated with the product or substance, its physical and chemical characteristics, when and how it may be hazardous, the effects of exposure, precautions for safe handling and use, emergency and first aid procedures, and control measures that are applicable.

Sometimes an SDS contains information that may not apply to your particular operation. In such cases, concentrate essentially on the information that is applicable to your situation. In general, employees should focus on the hazard information and what protective measures to take. Employers are required to maintain or make available to employees a complete and accurate SDS for each hazardous chemical that is used in the workplace.

OSHA has determined that drugs and medications that are not in solid or final form for direct administration to the patient fall within the scope of HAZCOM and, therefore, must be covered by SDSs. Accordingly, SDSs must be available for all drugs and medications that are liquid, gaseous, aerosol, etc., or not otherwise in solid, final form. SDSs for such products will be available from the EH&S office. SDSs for chemical products other than pharmaceuticals are available from the manufacturers or suppliers of the product and employers (users) are automatically entitled to this information upon purchase of the product.

Laboratory or Department Chairs will be responsible for obtaining and maintaining the SDSs for all hazardous materials in their laboratory inventory. When hazardous substances are received without an SDS and one is not available from a previous purchase, a letter with a copy to file should be sent to the supplier requesting the SDS. If the supplier fails to furnish the requested information, notify the University EH&S Office.
PIs or Department Chairs will ensure that any and all incoming SDSs are reviewed for new and significant health/safety information and pass any such information on to the

affected employees. This may be done through delegation. Copies of SDSs for all toxic and hazardous substances that any person working at the University may be exposed to must be readily accessible to all areas where the substances are used, handled, or stored. SDSs will be available to all employees for their review during each work shift. An electronic version of the SDS may be used as long as each employee who used the hazardous material has access to electronic version of the SDS. If an SDS is not available for any particular chemical or product, employees should contact their supervisor.

For assistance with interpreting and applying the information contained in the SDS, contact the University EH&S Office. To obtain a SDS:

- Ask your Laboratory Administrator, Department Chair, or Principal Investigator for the location of the SDS file.
- Contact the manufacturer of the product.
- Access information online at https://msdsmanagement.msdsonline.com/6455dc57-8e3e-4904-bd68-84e978899bf8/ebinder/?nas=True
-
- Contact the EH&S Office.

2.9.4 Safety Data Sheet Checklist

Each SDS will be checked to ensure that the following information is covered:

- Product or chemical identity used on the label.
- Manufacturer's name and address.
- Chemical and common names of each hazardous ingredient.
- Name, address, and phone numbers for hazard and emergency information.
- Preparation or revision date.
- Hazardous substances that comprise the product.
- The physical and chemical characteristics of the hazardous substances, such as vapor pressure and flash point.
- Physical hazards, including the potential for fire, explosion, and reactivity.
- Known health hazards, including signs and symptoms of exposure.

- OSHA PEL, American Conference of Governmental Industrial Hygienists (ACGIH) TLV or other exposure limits.
- Emergency and first aid procedures.
- Whether OSHA, National Toxicology Program (NTP), or International Agency for Research on Cancer (IARC) lists the ingredient as a carcinogen.
- Precautions for safe handling and use.
- Control measures such as engineering controls, work practices, hygienic practices, or personal protective equipment required.
- Primary routes of entry.
- Procedures for spills, leaks, and clean up.

2.9.5 Employee Training and Information

Under the OSHA HAZCOM Standard, employers are required to inform employees where hazardous chemicals and/or products, including pharmaceuticals, are present at the time of their initial assignment to a work area (i.e., the Howard University laboratory) as well as each time a new hazard is introduced into the work area.

PIs, Laboratory Administrators or Department Chairs are responsible for ensuring employees attend a HAZCOM training session, which is part of the initial/annual University EH&S training. Prior to starting work, each new employee will receive information and training on the following as appropriate with their respective jobs. Training will cover the following topics (at a minimum):

- An overview of the requirements contained in the OSHA HAZCOM Standard, 29 CFR1910.1200.
- Operations in their work area where hazardous chemicals, chemical products, or applicable pharmaceuticals are present.
- Location and availability of the written hazard communication program.
- Physical and health effects of the toxic or hazardous substances.
- Methods and observation techniques used to determine the presence or release of toxic and hazardous substances in the work area.
- How to use toxic and hazardous substances in the safest possible manner, including safe work practices and personal protective equipment requirements.

- Steps that University has taken to lessen or prevent exposure to toxic and hazardous substances.
- Emergency procedures to follow, if exposed to these toxic and hazardous substances.
- How to read labels and review SDSs to obtain appropriate hazard information.
- Location of SDS file and location of toxic and hazardous substances list.

For more information regarding the Howard University EH&S training program, please contact the University EH&S Office at [need information from client]

2.9.6 List of Hazardous Chemicals, Chemical Products, Applicable Pharmaceuticals

Each affected department will maintain a list, referred to as the Chemical Inventory, of all known toxic and hazardous substances present or used within their respective work areas. A copy of the Chemical Inventory is to be maintained in the laboratory's files and provided to the University EH&S Office. The inventory may be maintained by common chemical or trade names for each hazardous material. It is recommended to update this chemical inventory on a periodic basis (at a minimum on an annual basis or when significant additions or subtractions are made to the laboratory's inventory).

2.9.7 Hazardous Non-Routine Tasks

If employees are required to perform potentially hazardous non-routine tasks, each affected employee will be given information by the Department Chair or supervisor about any hazardous chemicals that they may be exposed to after consultation with the University EH&S office. This information will be given to the employee prior to starting work on such projects. This information will include:

- Specific hazards.
- Protective/safety measures the employee can take.
- Measures the University has taken to lessen the hazards including ventilation, respirators, presence of another employee, and emergency procedures.

An example of a non-routine task performed by staff at the University is the cleanup of minor hazardous materials spills.

2.9.8 Informing Contractors

Employees of outside contractors performing work at the University will be informed of any hazards that they might encounter from our operations prior to the beginning of the contract work. The PIs, Department Administrators, physical facility management (PFM), and/or the University EH&S office will provide outside contractors with the following information:

- Toxic and hazardous substances to which they may be exposed while on the Howard University job site.
- Precautions the employees may need to take to reduce the possibility of exposure, such as use of appropriate protective equipment.
- The availability and location of appropriate SDSs.

The PIs, Department Administrators, PFM, and/or the University EH&S office will also be responsible for contacting each contractor before work is started within the University's property in order to gather and disseminate any information concerning chemical hazards that the contractor may be bringing into the University. Contractors will be required to provide appropriate SDSs for review and approval as a condition of use on Howard University property.

Contractors will be required to abide by the University safety and health policies or guidelines. Violations of any such agreed upon terms may be cause for termination of the work until the condition is corrected.

2.10 CHEMICAL SPECIFIC PROCEDURES

2.10.1 Highly Hazardous Chemicals

Work with highly hazardous chemicals is often completed in research laboratories and cannot be avoided. When safer alternatives are not available, use and handling procedures can be developed and implemented with these highly hazardous chemicals. The section below defines highly hazardous chemicals based on the unique physical or toxicological properties of these compounds. Additional precautions are necessary when

using, handling, storing or disposing of these chemicals in order to maintain the optimum level of safety for laboratory and building personnel.

A risk assessment must be completed by the University EH&S Office in conjunction with research personnel, prior to working with the designated chemicals in Groups 2 and 3. The risk assessment will evaluate how the chemical is being used in the laboratory setting and determine what, if any additional engineering controls, PPE and/or administrative controls are necessary to control the hazard(s) associated with these chemicals.

Chemicals listed in Group 1 require specific guidelines, or SOPs, which must be developed by the laboratory. Researchers working with these chemicals are required to review and be trained on the corresponding guidelines prior to use.
Note: These lists are not exhaustive.

2.10.2 Highly Hazardous Designation

If a researcher reviews a SDS for a chemical and determines that it requires special precautions (e.g., respirator, localized exhaust) or has highly hazardous properties (e.g., highly toxic, air reactive, chronic health hazard) when working with the chemical, s/he must notify the University EH&S Office. This notification also applies if a chemical has a rating of 4 in one of the NFPA or the Hazardous Materials Information System (HMIS) hazard categories, since this rating indicates that the chemical is considered a highly hazardous chemical and as a result, it is covered by this Policy.

GROUP 1

The laboratory must develop guidelines or SOPS that must be followed when using these chemicals. Certain chemicals require air monitoring to ensure exposure is to low levels while others need proper training from the laboratory. (Note: if air monitoring is required, please contact the University EH&S Office). The EH&S online training may include information on some of these materials, however training is not all-inclusive; laboratories need to ensure their processes are safe.

- Alkali metals, (sodium, potassium, etc.)
- Anesthetic gases

- Azides (sodium azide, etc.)
- Carcinogens (known or suspected, not otherwise referenced in this list)
- Chromium hexavalent compounds
- Cyanides (potassium, sodium, etc.)
- Diaminobenidine (DAB)
- Dimethylbenzanthracene (DMBA)
- Ethidium bromide
- Formaldehyde
- Mercury compounds
- Nitric acid with a concentration > 40%
- Organic peroxides
- Osmium tetroxide
- Oxidizing gases
- Peroxide formers (ether, 1,4 – dioxane, tetrahydrofuran, etc.)
- Perchloric acid
- O - Phenylenediamine (OPD)
- Phenol
- Picrylsulfonic acid
- Sulfuric acid with a concentration <97%
- Tamoxifen
- Taxol
- Titanium tetrachloride
- Water reactive chemicals

GROUP 2

These chemicals require notification to the University EH&S Office when possessed and **prior to usage**:

- All cholinesterase Inhibitors that are not included in Group 1
- Flammable gases
- Fuming nitric acid, sulfuric acid, hydrochloric acid
- Hydrofluoric acid
- Kainic acid

- Known carcinogens (Report of Carcinogens by Department of Health and Human Services: http://ntp.niehs.nih.gov/?objectid=72016262-BDB7-CEBA-FA60E922B18C2540)
- N-ethyl-N-nitrosourea (ENU)
- Organo-mercury compounds
- Phorbol compounds

GROUP 3

These chemicals require approval from the University EH&S Office prior to ordering or purchasing. In addition, researchers working with these chemicals will require additional training on how to work with these chemicals.

Select Agents—Here is a list of common select agents used in a research setting. For a complete list of select agents, go to the following link: http://www.selectagents.gov/resources/List%20of%20Select%20Agents%20and%20Toxins_111708.pdf

- Botulinum toxin
- Conotoxin
- Ricin
- Saxitoxin
- Staph entertoxins
- Tetrodotoxin

Chemicals:

- Chlorine gas
- Dioxins (e.g., 2,3,7,8-tetrachlorodibenzodioxin (TCDD))
- Highly toxic (e.g., nickel carbonyl)
- Mustard gas
- Nerve agents (e.g., sarin, soman, tabun, VX)
- Neurotoxins (e.g., dimethyl mercury, 1-methyl-4-phenyl-1,2,3,6-tetrahydropyridine (MPTP), 1-methyl-4-phenylpyridinium (MPP+))
- Poisonous gases
- Pyrophorics (a.k.a. air reactive chemicals) (e.g., tert-butyl lithium)

REQUIREMENT MATRIX

The following matrix outlines the requirements for each group:

Group	Risk Assessment	SOP/Guideline Development	SOP/Guideline Training
Group 3	Prior to ordering or purchasing	Prior to ordering or purchasing	Prior to ordering or purchasing
Group 2	Prior to use	Prior to use	Prior to use
Group 1	Not applicable	Not applicable	Prior to use

2.10.3 Chemical Facility Anti-Terrorism Standard (CFATS)

The U.S. Department of Homeland Security (DHS) has issued a Standard that imposes federal security regulations for high-risk chemical facilities. This rule establishes risk-based performance standards for the security of the nation's chemical facilities and requires chemical facilities to prepare Security Vulnerability Assessments that identify security vulnerabilities at the facility and develop and implement Site Security Plans that include measures that satisfy the identified risk-based performance standards.

In order to determine if your facility meets the criteria for a high-risk chemical facility, the chemical inventories on campus must be reviewed. If the University manufactures, uses, stores or distributes any chemical above the Screening Threshold Quantities found in the DHS CFATS – Chemicals of Interest (http://www.dhs.gov/xlibrary/assets/chemsec_appendixa-chemicalofinterestlist.pdf) the University must complete and submit a Chemical Security Assessment Tool (CSAT) Top-Screen available on the DHS website: http://www.dhs.gov/files/programs/gc_1235582326154.shtm.

2.11 PROCESS SAFETY

Unexpected releases of toxic, reactive, or flammable liquids and gases in processes involving highly hazardous chemicals have been reported for many years in various industries that use chemicals with such properties. Regardless of the industry that uses

these highly hazardous chemicals, there is a potential for an accidental release any time they are not properly controlled, creating the possibility of disaster.

The major objective of process safety management of highly hazardous chemicals is to prevent unwanted releases of hazardous chemicals especially into locations which could expose employees and others to serious hazards. An effective process safety management program requires a systematic approach to evaluating the whole process. Using this approach the process design, process technology, operational and maintenance activities and procedures, non-routine activities and procedures, emergency preparedness plans and procedures, training programs, and other elements which impact the process are all considered in the evaluation. The various lines of defense that have been incorporated into the design and operation of the process to prevent or mitigate the release of hazardous chemicals need to be evaluated and strengthened to assure their effectiveness at each level. Process safety management is the proactive identification, evaluation and mitigation or prevention of chemical releases that could occur as a result of failures in process, procedures or equipment.

Laboratory staff members, the EH&S Office, and a representative from Facilities and Engineering should be part of the team conducting the process safety analysis.

Complete and accurate written information concerning process chemicals, process technology, and process equipment is essential to an effective process safety management program and to a process hazards analysis. The compiled information will be a necessary resource to a variety of users including the team that will perform the process hazards analysis; those developing the training programs and the operating procedures; contractors whose employees will be working with the process; those conducting the pre-startup reviews; local emergency preparedness planners; and insurance and enforcement officials.

The information to be compiled about the chemicals, including process intermediates, needs to be comprehensive enough for an accurate assessment of the fire and explosion characteristics, reactivity hazards, the safety and health hazards to workers, and the corrosion and erosion effects on the process equipment and monitoring tools. Current SDS information can be used to help meet this requirement which must be supplemented

with process chemistry information including runaway reaction and over pressure hazards if applicable.

Process technology information will be a part of the process safety information package and it is expected that it will include flow chart diagrams as well as employer established criteria for maximum inventory levels for process chemicals; limits beyond which would be considered upset conditions; and a qualitative estimate of the consequences or results of deviation that could occur if operating beyond the established process limits. Employers are encouraged to use diagrams which will help users understand the process.

A block flow diagram is used to show the major process equipment and interconnecting process flow lines and show flow rates, stream composition, temperatures, and pressures when necessary for clarity. The block flow diagram is a simplified diagram.

Process flow diagrams are more complex and will show all main flow streams including valves to enhance the understanding of the process, as well as pressures and temperatures on all feed and product lines within all major vessels, in and out of headers and heat exchangers, and points of pressure and temperature control. Also, materials of construction information, pump capacities and pressure heads, compressor horsepower and vessel design pressures and temperatures are shown when necessary for clarity. In addition, major components of control loops are usually shown along with key utilities on process flow diagrams.

Piping and instrument diagrams (P&IDs) may be the more appropriate type of diagrams to show some of the above details and to display the information for the piping designer and engineering staff. The P&IDs are to be used to describe the relationships between equipment and instrumentation as well as other relevant information that will enhance clarity.

A process hazard analysis (PHA), sometimes called a process hazard evaluation, is one of the most important elements of the process safety management program. A PHA is an organized and systematic effort to identify and analyze the significance of potential hazards associated with the processing or handling of highly hazardous chemicals. A PHA provides information which will assist employers and employees in making decisions for improving safety and reducing the consequences of unwanted or unplanned releases of

hazardous chemicals. A PHA is directed toward analyzing potential causes and consequences of fires, explosions, releases of toxic or flammable chemicals and major spills of hazardous chemicals. The PHA focuses on equipment, instrumentation, utilities, human actions (routine and nonroutine), and external factors that might impact the process. These considerations assist in determining the hazards and potential failure points or failure modes in a process.

The selection of a PHA methodology or technique will be influenced by many factors including the amount of existing knowledge about the process. Is it a process that has been operated for a long period of time with little or no innovation and extensive experience has been generated with its use? Or, is it a new process or one which has been changed frequently by the inclusion of innovative features? Also, the size and complexity of the process will influence the decision as to the appropriate PHA methodology to use. All PHA methodologies are subject to certain limitations. For example, the checklist methodology works well when the process is very stable and no changes are made, but it is not as effective when the process has undergone extensive change. The checklist may miss the most recent changes and consequently the changes would not be evaluated. Another limitation to be considered concerns the assumptions made by the team or analyst. The PHA is dependent on good judgment and the assumptions made during the study need to be documented and understood by the team and reviewer and kept for a future PHA.

2.12 WORKING WITH ANIMALS

The Institutional Animal Care and Use Committee (IACUC) has issued Guidelines and information for researchers and caregivers that addresses regulatory compliance, animal use, animal care, hazards and related issues (including the NIH Assurance) in relation to laboratory work with animals. These guidelines can be obtained from IACUC and the procedures should be followed for any research work involving animals. Information about the University IACUC can be found on Office of Regulatory Research Compliance (ORRC) website at www.howard.edu/orrc

2.13 LABORATORY INSPECTION PROTOCOL

2.13.1 Preparation

The following tasks are to be completed prior to the laboratory inspection:

- Research the principal investigator (PI) and the associated department to determine what is being performed in the laboratory; (This can be accomplished by searching the PI's name or the department on Google; reviewing the PI's research application with the Howard University Institutional Biosafety Committee (IBC); etc.)
- Read the previous laboratory inspection reports; look for reoccurring observations;
- Review the chemical inventory for each room associated with the PI (Are there any highly hazardous chemicals? Refer to the Highly Hazardous Chemical SOP; (section 2.10 provides more information)
- Verify that the chemical inventory was reviewed and updated in the past year;
- Review hazardous waste work orders associated with the PI;
- Review the Evacuation Plan for the laboratory and/or office area(s), confirm they are correct and were submitted in the last year;
- Contact PI/Laboratory Manager/Safety Contact to schedule the laboratory inspection; and
- Provide PI/Laboratory Manager/Safety Contact a copy of the laboratory inspection form for their review and use.

2.13.2 Inspection

2.13.2.1General Inspection

With laboratory contact, the inspector should:

- Introduce himself/herself with a brief description of his/her role within the EH&S Office and his/her experience.
- Provide a description of the laboratory inspection process.
- Compare the NFPA 704 signage with the chemical inventory.
- Confirm that the NFPA 704 sign is current and correct.
- Tour laboratory areas associated with the PI/Laboratory Manager/Safety Contact (laboratory bench top areas, storage areas, and common areas [i.e., equipment halls]).

NOTE: The PI/Laboratory Manager/Safety Contact can either stay with the inspector or leave at this point. It is up to the PI/Laboratory Manager/Safety Contact whether or not s/he wants to stay or not. However, it is preferred that the PI/Laboratory Manager/Safety Contact stay so that s/he witnesses the entire inspection.

2.13.2.2 Detailed Inspection

With or without PI/Laboratory Manager/Safety Contact, the inspector should:

- Use laboratory inspection form to determine compliance with applicable regulations and best management practices.
- Inspect work practices in the laboratory.
  - Are researchers wearing PPE such as laboratory coats, gloves and/or face/eye protection (as appropriate) when working with hazardous chemicals?
  - Have someone show where the PPE is stored and how they dispose of contaminated PPE.
  - Ensure all laboratory and administrative personnel have attended the appropriate EH&S training within the past year.
  - Ensure equipment (e.g., freezers) and building (e.g.,HVAC system; chemical fume hoods, etc.) is functioning properly.
- Conduct a thorough inspection of the Chemical Storage Areas within the laboratory for proper storage. This means look at every bottle of hazardous chemical. Here are some guidelines:
  - Ensure flammables are stored in rated cabinets
  - Ensure acids are stored in acid rated cabinets
  - Ensure bases are stored in base rated cabinets
  - Check to see if peroxide formers are stored properly; appear in good condition; are not past or approaching expiration date
  - Ensure water reactive chemicals are stored together and away from moisture
  - Ensure all chemicals that pose significant risk have an SOP outlining their safe usage
  - Ensure chemicals are stored by chemical compatibility not alphabetically
  - Ensure containers of hazardous chemicals are labeled with the name of the chemical and the hazard associated with it. Also, recommend that all containers be labeled with their contents for emergency response assistance.

- Open every drawer, freezer, refrigerator, cabinet, etc. to ensure no chemicals are being improperly stored in the laboratory area.

2.13.2.3 Document and Inspection Review

After detailed inspection, meet the PI/Laboratory Manager/Safety Contact, to review the laboratory inspection and EH&S practices associated with his/her laboratory. Use the inspection form as a guide for this phase of the inspection:

- Does the laboratory know how to obtain regulatory documents (i.e., EH&S/Safety Manual; Chemical Hygiene Plan)?
- Who are the appropriate contacts for incidents and emergencies?
- What are the appropriate procedures for incidents and emergencies?
- Discuss the observations associated with the inspection using regulatory or scientific information to support observation.
- Provide ways to improve compliance with EH&S.
- Answer any questions; if you are unsure of the answer, indicate that you need to research the item and you will follow-up with a phone call with the supporting information.
- Inform them that the inspection report will be sent to Laboratory Manager/Safety Contact and the PI via e-mail for their use and review, indicating any corrective measures to be completed in 30 days
- Another inspection will be conducted after the inspection report is submitted to the EH&S Office to confirm that the observations have been corrected by the laboratory.

2.13.3 Follow-Up

- Respond via phone with any information requested during the inspection. Document conversation in a log book.
- Enter information into the inspection database.
- Have another EH&S staff member proof read the inspection report before generating it.
- Generate inspection report in a pdf format.
- Submit inspection report to PI/Laboratory Manager/Safety Contact.

- If the inspection report is not submitted back to the EH&S Office within one month, contact the PI/Laboratory Manager/Safety Contact to determine the status of the inspection report observations.

2.14 RECORD KEEPING

It is important to maintain a complete record of EH&S related matters including training records, hazard evaluations, inspection results, incident reports, hazardous waste manifests, etc. In the event that a regulatory agency inspects, these records may need to be available to produce upon request by the inspector. Ensure that record keeping is in compliance with all applicable regulations pertaining to the laboratory as stated in Section 2.2.

3.0 BIOLOGICAL SAFETY

3.1 BACKGROUND

Biosafety is defined as a group of practices and procedures designed to provide a safe working environment for individuals working with and around potentially hazardous biological materials in the laboratory. The primary goal of biosafety is to reduce or eliminate risk of exposure to these agents through the use of containment. Containment refers to safe methods for managing potentially infectious materials (PIM) in laboratory environments. Containment includes not only good microbiological techniques and safety equipment (primary containment), but also the design and operation of the laboratory facility (secondary containment).

Two government agencies, the National Institutes of Health (NIH) and the Centers for Disease Control and Prevention (CDC), developed the biosafety guidelines that provide the foundation for this manual. These guidelines are designed to protect laboratory personnel and individuals in the surrounding community, and are described in two publications. The first is the *National Institutes of Health Guidelines for Research Involving Recombinant DNA Molecules (NIH Guidelines)*, http://oba.od.nih.gov/rdna/nih_guidelines_oba.html, which was last revised in 2011. The second is Biosafety in Microbiological and Biomedical Laboratories (BMBL), which is published jointly by the CDC and the NIH, http://www.cdc.gov/biosafety/publications/bmbl5/, and was last revised in 2009.

The NIH Guidelines and the BMBL classify work with biological agents into four distinct biosafety levels (BSLs). Each of these levels is matched with progressively more stringent practices and laboratory design features that have been developed to reduce the risk of exposure to potentially hazardous biological agents. All laboratories at the University work at BSL1 or BSL2. The following table summarizes BSL1 and BSL2 requirements.

Table 3.1 Summary of Biosafety Level Criteria for BSL1 and BSL2

Biosafety Level	Agents	Practices	Safety Equipment (Primary Barriers)	Facilities (Secondary Barriers)
BSL1	Not known to consistently cause disease in healthy adults	Standard Microbiological Practices	Personal Protective Equipment (PPE) includes laboratory coats; gloves; eye protection as needed	• Doors for access control • Sink for hand washing • Work surfaces, floors, benches, and furniture should be impervious to moisture, easily cleaned/disinfected, and resistant to heat and chemicals.
BSL2	Associated with human disease. Potential hazards from percutaneous injury, ingestion, and mucous membrane exposure.	BSL1 practices plus: • Limited access • Biohazard signs • PPE • Disposal or proper cleaning of PPE • Sharps precautions • Biosafety manual that defines any biological waste decontamination policies	• Primary barriers include Class I or II biosafety cabinets or other physical containment devices for all manipulations of agents that cause splashes or aerosols of infectious materials. • PPE includes laboratory coats; gloves; eye and face protection, as needed	BSL1 plus: • Self-closing, lockable doors • Properly-installed biosafety cabinets (refer to BMBL) • In-line vacuum filters • Readily accessible eyewash station. • A method for decontaminating all laboratory wastes should be available in the facility (e.g. autoclave, chemical disinfection, incineration, or other validated decontamination method).

PPE personal protective equipment

3.2 REGULATIONS

Federal agencies have developed regulations for protecting laboratory workers and the general public from potential health hazards associated with the use of biological agents in laboratories. Some of these regulations, such as those from the OSHA, have the force of law while those from the NIH and CDC are recommended guidelines. The University requires adherence to both the suggested federal guidelines and the federally mandated requirements.

OSHA developed the Bloodborne Pathogens (BBP) Standard (29 CFR 1910.1030) to minimize occupational exposures to blood and other bodily fluids and to prevent developing the infectious diseases, such as human immunodeficiency virus (HIV), hepatitis B virus (HBV), and hepatitis C virus (HCV), associated with them. All laboratories that work with human blood, other bodily fluids, or tissues must adhere to the OSHA BBP Standard (http://www.osha.gov/SLTC/bloodbornepathogens/index.html). At the University, work with these materials must be reviewed and approved by the University Institutional Biosafety Committee (IBC) and work is conducted at BSL2.

The use of Universal Precautions is a key element of a BBP exposure control program and must be followed at all times in BSL2 laboratories. Universal Precautions involves treating all human blood (even HIV-seronegative control donors), tissue, or materials as potentially infectious. Training in Universal Precautions techniques is given at the time of orientation and on an annual basis. This training is offered through the University EH&S Office and ORRC. For more information, contact EH&S at (202) 806-1033 or ORRC at (202) 865-8597.

Safe practices for studies involving the use of rDNA are governed by the NIH Guidelines (http://oba.od.nih.gov/rdna/nih_guidelines_oba.html). The NIH places the responsibility for implementing its guidelines in the hands of an IBC. The IBC reviews all research at the University that involves the use of rDNA and infectious agents, and researchers must submit an application to the University IBC prior to beginning any new research involving the use of these agents.

3.3 INSTITUTIONAL BIOSAFETY COMMITTEE

[Need client information]

3.4 ROLES AND RESPONSIBILITIES

Everyone at the University is responsible for maintaining a safe and compliant environment. Some of the roles and responsibilities regarding biosafety are listed below.

3.4.1 Principal Investigator (PI)

PIs are responsible for implementing applicable biosafety procedures and practices in their laboratories. They must ensure that the appropriate equipment and facilities are available for laboratory staff members and that they are used properly. They must also arrange for appropriate employee training regarding the safe use of potentially hazardous biological agents and require that individuals handling BBPs receive the annual training mandated by OSHA. Each PI must be aware of the potential adverse health effects of the biological materials used in his or her laboratory, the appropriate biosafety level, and any other pertinent factors that will ensure the safety of laboratory staff members and the surrounding community.

In addition to the responsibilities of the PI above, when research involves the use of rDNA, the PI agrees to abide by the NIH Guidelines. Under the NIH Guidelines, the PI has a number of specific responsibilities. In particular, the Principal Investigator must (among other tasks):

- Ensure that no research is conducted with regulated biological materials prior to approval by the IBC.
- Report any significant problems, violations of the NIH Guidelines, or any research-related accidents, illnesses, or potential exposures to BSO at (202) 806-9710.
- Instruct and train laboratory staff in: (i) the practices and techniques required to ensure safety, and (ii) the procedures for dealing with accidents. This instruction should be specific to the agents and materials used in the research project.
- Make protocols describing the potential biohazards and safety precautions associated with the agents to be used available to laboratory staff.

Additional responsibilities of the PI when working with rDNA are located in the NIH Guidelines (http://oba.od.nih.gov/rdna/nih_guidelines_oba.html). One PI's failure to comply with the NIH Guidelines could affect all NIH-funded projects at the University; therefore, compliance is absolutely mandatory.

3.4.2 Laboratory Staff and Student Responsibilities

Laboratory staff and students are responsible for following the University health and safety policies and the procedures and instructions from their PIs/Instructors. They need to comply with the NIH, CDC and OSHA regulations, use safe laboratory practices, and inform the PI, laboratory supervisor, or regarding any potentially hazardous situations or conditions.

3.4.3 Biosafety Officer

Responsibilities of Biosafety Officer include but not limited to:

- Developing, implementing and coordinating biological safety program for the University.
- Reviewing protocols involving biological materials and recombinant DNA and potential biohazards.
- Reviewing selected agents transfer to and from the University (i.e., Material Transfer Agreement (MTA)).
- Acting as resources for the University on various regulations and guidelines pertaining to the use, handling and disposal of potential biohazards and recombinant DNA.
- Inspecting research and teaching facilities for compliance with regulations involving the use, handling and disposal of potential biohazards and recombinant DNA.

3.5 RISK ASSESSMENT

In order to determine which practices and procedures are required when working with biological materials, a risk assessment should be conducted. At a minimum, the risk assessment should include the following:

- Pathogenicity of the biological material and infectious dose
- Potential outcome of an exposure
- Natural route of exposure
- Other routes of exposure (parenteral, airborne, ingestion, etc.)

- Stability of biological material in the environment
- Concentration of biological material and amount to be manipulated
- Presence of a suitable host
- Information available from animal studies and reports of laboratory-acquired infections or clinical reports
- How the biological material will be used (concentration, sonication, aerosolization, centrifugation, etc.)
- Any genetic manipulation of the organism that may extend the host range of the agent or alter the agent's sensitivity to known, effective treatment regimens
- Local availability of effective prophylaxis or therapeutic interventions

In situations where the information is insufficient to perform a risk assessment, the following conservative approach should be used:

- Universal precautions should always be followed, and barrier protections applied (Gloves, gowns, eye protection), regardless of the origin of the samples.
- Biosafety level 2 should be the minimum requirement for the handling of specimens.

Biological expression systems consist of vectors and host cells. When conducting a risk assessment of these systems, consider whether the following concerns apply:

- Does the expression of the DNA sequences derived from pathogenic organisms increase the virulence of the genetically modified organism (GMO)?
- How well-characterized are inserted DNA sequences?
- Do gene products have potential pharmacological activity?
- Do gene products code for toxins?
- Will a human oncogene be inserted, or will a tumor suppressor gene be silenced?

3.6 BLOODBORNE PATHOGENS

The federal government issued the OSHA BBP Standard (29 CFR 1910.1030) in December 1991. The primary purpose of the BBP Standard is to minimize the risk of occupational exposures to blood and other bodily fluids and protect workers from the infectious diseases associated with them. In addition to HIV and the hepatitis viruses, the BBP Standard covers a wide variety of bloodborne infectious agents that can cause disease. Some of the included agents are simian immunodeficiency virus and the

biological agents that cause syphilis, malaria, babesiosis, brucellosis, leptospirosis, relapsing fever, arboviral infections, Creutzfeldt-Jacob disease, and viral hemorrhagic fevers.

Sources of potential exposures to BBP include human blood and a variety of potentially infectious materials (PIMs). The OSHA definition of human blood includes whole blood, blood products, and blood components. PIMs include body fluids, such as saliva, semen, vaginal, cerebrospinal, synovial, pleural, peritoneal, pericardial, amniotic fluids, anybody fluid in which visible blood is present, and any unfixed tissue or organ from a human either living or dead. Cell or tissue cultures, organ cultures, or media containing HIV, HBV, or HCV are also included.

OSHA has designated the term “standard precautions” as the approach for controlling against infections from BBP. The concept is that all human blood and PIMs are treated as if they contain HIV, HBV, or other BBP. In the laboratory environment, BL2 practices and containment are required for activities involving BBP.

All personnel with potential occupational exposures to BBP must receive annual training in accordance with the BBP Standard. Supervisors are responsible for ensuring that all employees with potential occupational exposures to BBP participate in this training.

3.7 EXPOSURE CONTROL PLAN

The BBP Standard requires that an Exposure Control Plan (ECP) be written and implemented and that a copy of the ECP be made available to employees. The ECP includes several required elements, policies, and procedures that are designed to eliminate or minimize BBP exposures. The purposes of the plan are to:

- Protect staff and students from the health hazards associated with BBP.
- Coordinate appropriate treatment and counseling in the event of a BBP exposure incident.

The following procedures have been implemented to identify individuals that have occupational exposures to BBP. Each staff member is classified as either exposed or unexposed and is informed of their classification by respective supervisors.

1. Job classifications have been identified in which:
    a. All employees have occupational exposure to BBP.
    b. Some employees have occupational exposure to BBP.

These classifications are based on the individual's potential for coming in contact with any potentially infectious material and/or their duties as they relate to work in the laboratory. Employees with no exposure are also identified. Department managers or supervisors are responsible for reviewing and modifying their employee's classification as exposed or unexposed based on detailed knowledge of the employee's work responsibilities.

2. Lists of tasks and procedures during which occupational exposure may occur are maintained for employees identified above in 1b.

PIs are responsible for ensuring the effectiveness of and compliance with the following controls and practices.

3.8 ENGINEERING CONTROLS

Engineering controls, such as hand washing facilities, sharps disposal containers, leak-proof containers for human blood and tissue samples, and biological safety cabinets, minimize the risk of exposure to BBP and PIMs. New engineering controls will be evaluated and implemented as they become available.

3.9 IMMUNIZATIONS AND MEDICAL RESTRICTIONS

Immunizations or medical restrictions may be recommended or required if working with certain biological materials. Personnel working with human blood or PIMs, Vaccinia virus, Influenza virus, or other pathogens should discuss immunizations and/or medical restrictions with their PIs, occupational health and safety department and/or primary care physician.

The HBV vaccination is available, at no cost, to all staff members who have occupational exposures to BBP. Those who decline to take part in the vaccination program must sign the "Vaccination Declination Form" and will have the opportunity to be vaccinated at a later date.

Several infectious agents are known to affect embryonic development. Anyone who may become pregnant or who lives with someone who is pregnant or may become pregnant should be aware of the risks associated with these agents. The following is a partial list of infectious organisms that may have an adverse effect on human embryo and fetal development.

- Rubella virus
- Herpes simplex virus
- Varicella virus
- Toxoplasma
- HIV
- Influenza virus
- Mumps virus
- Parainfluenza type 2

This is not an all-inclusive list. Anyone wishing to become pregnant should inform her obstetrician and gynecologist of any infectious agents and chemicals encountered in her work.

Other medical restrictions or recommendations may be made on an individual basis after discussion with either an occupational medicine practitioner or personal physician.

Examples of some conditions that might warrant special precautions are HIV infection, immunosuppressive conditions, or drug therapy that suppresses the immune system. Anyone affected by these or other conditions should discuss exposure control options prior to beginning work that may expose him/her to infectious agents.

3.10 LABORATORY PRACTICES

3.10.1 Personal Protective Equipment

PPE is an essential element laboratory safety. PPE includes, but is not limited to:

- Gloves
- Laboratory coats (impervious)

- Face shields/masks
- Safety glasses/Prescription safety glasses
- Goggles
- Hoods
- Shoe covers
- Respiratory protection
- Other site-specific personal protective equipment

At a minimum, laboratory personnel shall wear gloves and a laboratory coat whenever handling biological agents, cells and tissues. Safety glasses with side shields, goggles, or face shield shall be worn when these materials could potentially be splashed in the face. Laboratory personnel should wear other personal protective equipment (apron, face shield, mask, etc.) as needed or required to prevent potentially infectious materials from reaching their clothes, skin, eyes, mouth, or other mucous membranes. PPE must be removed prior to leaving the work area and placed in designated areas. PPE must be treated as medical waste when discarded. If PPE is not disposable, PPE shall be cleaned with disinfectant before and after use.

3.10.2 Biological Safety Cabinets

Biological safety cabinets (BSCs) provide a primary level of containment for working safely with potentially hazardous biological materials. When combined with standard microbiological practices, BSCs can protect both laboratory personnel and the environment. Although some may think that the purpose of BSCs is to protect cells and cultures from contamination by bacteria and fungi, **their primary purpose is to protect the laboratory workers from exposures to potentially infectious agents.**

BSCs are designated as Class I, II, or III based on specific airflow patterns within the BSC and on the locations of high efficiency particulate air (HEPA) filters within the unit. HEPA filters are usually composed of a pleated sheet of borosilicate fiber material that has been treated with a wet-strength water-repellant binder. These filters are specifically designed to remove particles equal and greater than 0.3 microns with an efficiency of 99.97%. This filtration level will capture a majority of bacteria, spores, and viruses from the filtered air.

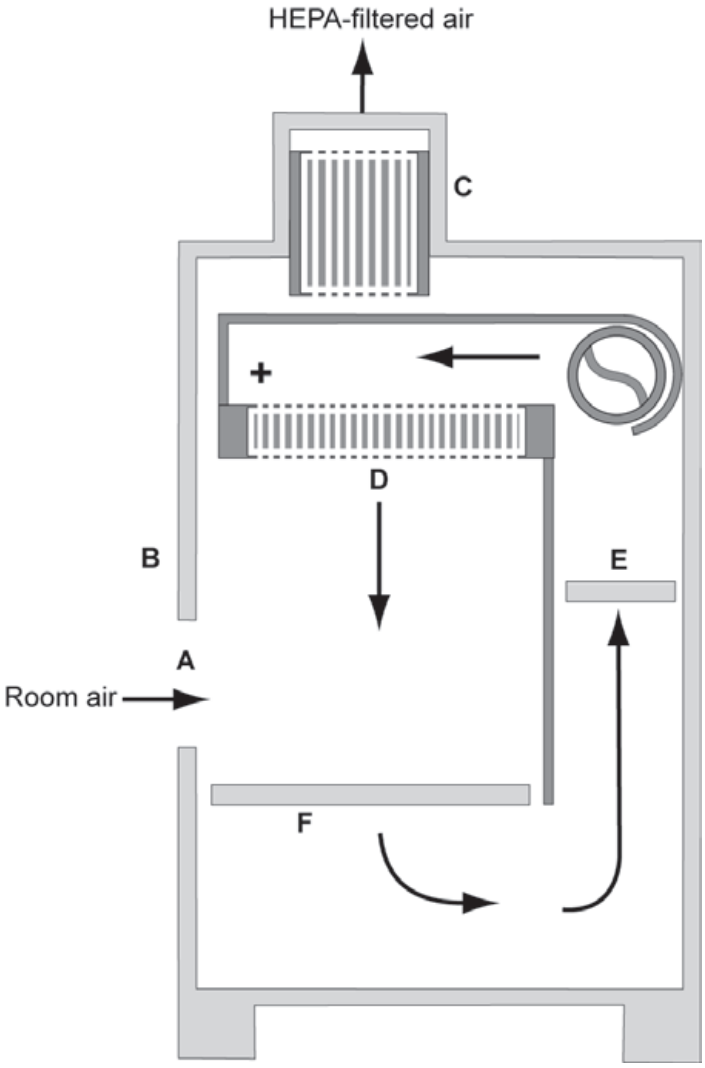


Figure 3.1 Tabletop Model of a Class II, Type A2 Biosafety Cabinet

(A) front opening; (B) sash; (C) exhaust HEPA filter; (D) supply HEPA filter; (E) positive pressure common plenum; (F) negative pressure plenum. The Class II Type A2 BSC is not equivalent to what was formerly called a Class II Type B3 unless it is connected to the laboratory exhaust system. Note: The A2 BSC should be canopy connected to the exhaust system. (Figure taken from *Biosafety in Microbiological and Biomedical Laboratories*, Fifth Edition, 2009.)

Implementation of the following procedures will ensure optimal operation of a BSC:

- Front and rear grills should be free of clutter to allow proper air intake.
- Sash should not be raised above the specified level.
- Bunsen burner use will cause airflow disruptions and damage to the HEPA filter, and should be avoided
- Certification must be performed annually.

BSCs are required to be tested and certified annually by technicians accredited by the National Sanitation Foundation (NSF International). Additionally, BSCs will be certified when they are first installed and whenever they are moved, even to a nearby laboratory, because the HEPA filters may be dislodged from their proper fitting during these moves.

3.10.3 Biological Waste Procedures

Biological waste may be disposed of in three ways: designated biological waste box, chemical disinfection, and steam sterilization/autoclave. Appropriate disinfection procedures will be chosen and utilized in accordance with both the PI and the BSO in order to ensure adequate decontamination of biological wastes.

Liquid biological waste must be rendered non-infectious by steam sterilization or chemical disinfection prior to sink disposal. If chemical disinfection is selected, full-strength household chlorine bleach may be added to the waste container, such as an aspiration flask, so that the **final** solution concentration of bleach will be 10%. Contact time should be at least 30 minutes prior to sink disposal for bleach.

NOTE: If bleach is not an adequate disinfectant for the biological agent in use, an U.S. Environmental Protection Agency (EPA) approved disinfectant must be used. Ensure the proper contact time prior to disposal.

Before disposing of the treated solution down the sink, check the pH to ensure it is within the permissible pH r**ange** (5.5 – 12.0 standard units). If it is within the permissible range, then disposal of the treated solution in the sink should be done with running tap water to minimize possible plumbing damage due to the corrosive effects of the disinfectants. Autoclaving solutions containing bleach is **not permitted** due to the potential for production of toxic chlorine gas.

3.10.4 Sharps Management

Some of the most serious accidents in biological laboratories are those caused by puncture wounds through skin (percutaneous exposures). All objects that can puncture skin are designated as sharps and require special disposal treatment. Examples of sharps include hypodermic needles, glass Pasteur pipettes, razor blades, broken glass, and

suture needles. Sharps must be disposed of separately from all other waste streams and sharps containers cannot be disposed of with other biological waste.

Federal regulations concerning sharps primarily focus on work with human bodily fluids. Research work conducted with animals only is not required to utilize engineered sharps; however, it is recommended that engineered devices be used whenever practical. Because the majority of laboratory biohazard injuries are due to hypodermic needles, special attention has focused on their use and disposal. Some guidelines include:

- Minimize use of needles and syringes.
- Do not bend, shear, or break needles.
- Do not recap needles.
- Do not remove needles from syringes.
- Throw away the entire syringe-needle combination.
- Be careful during cleanup; some sharp items may be hidden in the waste materials.
- If a needle stick occurs, encourage the wound to bleed for a few minutes, wash the area, and then get medical attention immediately.

In 2001, in response to the *Needlestick Safety and Prevention Act*, OSHA revised the BBP Standard 29 CFR 1910.1030. The revised standard clarifies the need for employers to select safer needle devices and to involve employees in identifying and choosing these devices. The updated standard also requires employers to maintain a log of injuries from contaminated sharps. Further information can be found at http://www.osha.gov/SLTC/bloodbornepathogens/index.html.

To prevent injury from sharps, place all needles, Pasteur pipettes, syringes, suture needles, scalpels, and razor blades into standard sharps containers. Large volumetric/serological pipettes, or other items that can puncture the biological waste red bags should be disposed of in Sharps Boxes. Sharps containers must be leakproof, rigid, puncture-resistant, shatterproof containers that that are marked prominently with the universal biohazard warning symbol and the word “Biohazard” in a contrasting color. Place sharps containers in convenient locations near work areas so they will be used. **Do not overfill the sharps containers.** Containers should be sealed when they are three-quarters (3/4) full.

3.10.5 Disinfection, Decontamination, and Sterilization Methods

Disinfection and decontamination are terms that are often used interchangeably, but they each have specific definitions. Disinfection is a chemical or physical treatment that eliminates many or all pathogenic microorganisms, except bacterial spores, on inanimate objects. Decontamination refers to a chemical or physical treatment that removes pathogenic microorganisms from objects so they are safe to handle, use, or discard. A number of disinfectants are commonly used in laboratory settings, particularly to wipe down surfaces to remove infectious agents. Types of disinfectants and their uses are summarized in Table 4.2.

Table 3.2 Summary of Disinfectants and Their Uses

Disinfectant	Final Concentration	Effective On	Ineffective On
Sodium Hypochlorite Bleaches: e.g., Clorox™*	1:10	Bacteria, some spores, viruses, TB†, HIV	Some spores
Chlorine Dioxide: e.g., Clidox®-S*	1:5:1 or 1:18:1	Bacteria, spores, viruses, TB	
Alcohols (Ethanol, Isopropanol)	70%	Bacteria, most viruses	Spores, TB
Quaternary Ammonium Compounds: e.g., Quatricide®*	Ready to use	Bacteria, spores, viruses, TB	

TB tuberculosis
HIV human immunodeficiency virus

* The use of brand names does not imply a recommendation.
† Use 1/5 dilution

Sterilization is a chemical or physical treatment that destroys or neutralizes all forms of microbial life. The most common method of sterilization in a laboratory setting is autoclaving. Autoclaves work by denaturing biological molecules with superheated steam; dry heat is not nearly as effective. For example, it takes 12 minutes to kill most spores with steam at 121 degrees Celsius (°C), while 6 hours are required with dry heat at the same temperature. It is the steam that kills.

As a result, anything that does not come in contact with steam inside the autoclave may not be adequately decontaminated. The potential for inadequate decontamination

becomes a greater concern when sealed biohazard bags are placed in an autoclave. There are two simple solutions: 1) cut open the bag, or 2) place about 200 milliliters of water in the bag before sealing.

Typically, bags (24" x 36") of solid plastic waste take from 45 minutes to 1 hour to reach sterilizing temperatures throughout its contents.

Autoclaves should be tested routinely and validated to insure that they are operating properly and killing the biological organisms in each autoclave load. The preferred method for autoclave validation is to test it with a commercial spore test system. This system contains a color indicator and a thermophilic bacterial species, such as *Bacillus stearothermophilus*, that is tolerant to high temperatures. The system is autoclaved under realistic conditions, such as in the middle of a bag of waste, and then incubated. If the spores grow, a color change will occur indicating inadequate sterilization in the autoclave. If there is no growth, no color change occurs and the autoclaving procedure is adequate.

Using an established autoclave test procedure, quarterly checks with a biological indicator are usually adequate to assure proper autoclave function and to detect gradual deterioration of operation. It is important to note that autoclave tape indicates only that a critical temperature was reached; it **does not** indicate the length of time at the desired temperature or whether steam was present.

In the research laboratory setting, the target organisms to be killed are usually known and are usually heat sensitive. In practice, the same autoclave is used for sterilizing laboratory materials and waste. If sterilized materials are subsequently determined to be contaminated, it is an indication that the autoclave is not working properly.

The following tips will help prevent injury and property damage when using the autoclave.

- Do not overfill containers. Leave the top third as empty expansion space.
- Use only vented closures.
- Place contaminated materials in autoclave bags. Place bags inside plastic or metal trays when autoclaving.
- Use only containers designed for sterilization. Use plastic or metal trays.

Bottles should be cool to the touch before attempting to remove them. Do not place hot bottles directly on a room temperature or cool surface. Tighten screw caps when the liquid is completely cooled.

3.10.6 Spill Response

The following procedures are recommended for the management of small spills of blood, body fluids, or other potentially infectious materials in the laboratory or in a biosafety cabinet.

- Put on protective clothing (laboratory coat, gloves, face and eye protection, and shoe covers) and assemble clean-up materials (disinfectant, autoclavable container or bag, forceps, and paper towels).
- If the spill has occurred in a biosafety cabinet, keep the cabinet turned on.
- Spray the affected area with a disinfectant, such as a fresh 10% bleach solution.
- Pick up any broken glass with forceps and dispose it in a sharps container.
- Let disinfectant sit for 30 minutes.
- Soak up the disinfectant and spill with paper towels.
- Discard all clean-up materials in a biological waste box. Autoclave any reusable items, such as laboratory coats.
- Remove PPE and place disposable PPE into a biological waste box. Reusable PPE should be cleaned with the proper disinfectant.
- Wash hands and exposed skin areas thoroughly with soap and water.

The following procedures are recommended for a large volume biological spill in the laboratory area, in a BSC, or if equipment malfunctions while processing biological materials:

- If the spill occurs in a BSC, close the sash and leave the BSC running.
- Keep people out of the area to prevent spread of the contamination. Put up a warning sign indicating that there was a spill in the BSC, the steps taken to treat/contain the spill, and contact information for a responsibly party.
- Remove any contaminated clothing and put it into a biohazard bag for decontamination later.

- Wash hands and exposed skin thoroughly with soap and water.
- Call BSO at (202) 806-9710 to report the size, location, and composition of the spill.

3.11 SHIPPING OF HAZARDOUS MATERIALS

Import, export, and interstate transport of hazardous materials are subject to requirements and laws from several regulatory agencies. The U.S. Public Health Service (PHS), U.S. Department of Transportation (DOT), U.S. Department of Agriculture (USDA), and U.S. Postal Service, regulate transport of hazardous materials by rail, air, vessel, and public highway. The guidelines and regulations of the International Air Transport Association (IATA) and International Civil Aviation Organization also apply when shipping substances by air. Import/Export Permit requirements are regulated by the Bureau of Customs; the Department of Commerce, CDC, and USDA require permits for certain materials. Materials considered hazardous and regulated for shipping purposes include hazardous chemicals, wastes, etiologic agents, infectious substances, diagnostic specimens, and dry ice.

The PHS defines etiologic agents as viable microorganisms that cause disease in humans; infectious substances are those substances that contain etiologic agents. This terminology is used by the DOT and IATA. Diagnostic specimens are anything that the shipper reasonably believes to contain an infectious substance. Diagnostic and infectious specimens are regulated by the USDA, U.S. Food and Drug Administration (FDA), PHS, and IATA. Biological product means a product prepared in accordance with regulations that govern the manufacture of vaccines, reagents, or all viruses, serums, toxins, etc. intended for use in the diagnosis, treatment, or prevention of diseases in humans or animals. Biological products are regulated by the USDA, FDA, PHS, DOT, and IATA.

Laboratory staff may receive awareness training from EH&S office for the shipment of hazardous materials. Individuals packaging specimens/hazardous materials for shipment must receive function-specific training. The training is required every two years or when there is change in the regulations. For assistance regarding training and other requirements necessary for the legal shipping of hazardous materials, please contact EH&S office at (202) 806-1033.

4.0 ELECTRICAL AND MECHANICAL SAFETY

4.1 BACKGROUND

Electrical and mechanical safety are important components of a comprehensive Laboratory Environmental Health and Safety program. This section will outline regulatory requirements, risk and controls associated with electrical and mechanical hazards in laboratory facilities, and ways to minimize potential risks.

4.2 REGULATIONS

Machinery and Machine Guarding, 29 CFR 1910 Subpart O, requires machine guards to be in place on any equipment where machine parts and/or functions may cause injury, and prohibits the removal of guards from machinery.

The Control of Hazardous Energy (Lockout/Tagout), 29 CFR 1910.147, requires specific practices and procedures to safeguard employees from the unexpected energization or startup of machinery and equipment, or the release of hazardous energy during service or maintenance activities.

4.3 HIGH VOLTAGE

The National Electrical Code, NFPA 70 (2011), defines *high voltage* as any voltage over 600 Volts. The University laboratory employees will not perform work on high voltage circuits.

4.4 ALTERATIONS TO EXISTING EQUIPMENT

Alterations to existing equipment must not be made except by authorized and qualified employees, or without design and process input from appropriate professional experts, which may include the University EH&S and Facilities, electrical and/or mechanical engineers, and technical representatives of the manufacturer of the equipment.

No equipment may be altered by removing machine guards which were part of the equipment as designed and provided by the manufacturer.

4.5 MACHINE GUARDING

Machine guarding is required by OSHA under 29 CFR 1910.211. A guard is a barrier that prevents the entry of the operator's hands or fingers into any part of a machine or piece of equipment where they may be cut or caught between moving parts, between moving and stationary parts, or between the material and moving parts of the machine.

Guarding is required of machine tools. Hand-held, portable power tools, or manual tools are not required to be guarded.

Machine guarding provided by the manufacturer should never be removed from the machine.

4.6 LOCKOUT/TAGOUT

Listed below are general procedures and rules for lockout/tagout required by the OSHA standard.

- All equipment shall be locked or tagged out to protect against accidental or inadvertent operation when such operation could cause injury to personnel.

  No one shall attempt to operate any switch, valve, or other energy isolating device where it is locked or tagged out.

- Lockout (vs. tagout) must be used when the energy isolating device is capable of being locked out.

- Tagout without lockout shall only be used when the energy isolating device is not capable of being locked out. When tagout alone is used, the following conditions must be met:

  - The tagout device must be attached at the same location the lockout device would have been attached.

- The tagout procedure must provide protection equal to that provided by a lockout procedure through the implementation of additional measures. Examples of such measures are:

    - Removing an isolating circuit element.
    - Blocking a controlling switch.
    - Opening an extra disconnecting device.
    - Removing a valve handle to reduce the likelihood of inadvertent energization.
    - Positioning standby personnel at the tagout location.

- Whenever major replacement, repair, renovation, or modification of machines or equipment is performed, the energy isolating device shall be designed to accept a lockout device.

- No new machines or equipment shall be installed unless the energy isolating device is capable of accepting a lock.

- **Only authorized employees** are permitted to implement a lockout/tagout procedure. Authorized employees must be trained in accordance with the OSHA standard. The names of those authorized to implement lockout/tagout on a machine or a piece of equipment must be identified in writing.

- Lockout and tagout devices must be standardized for the facility. Each affected department is to have their own identifiable lockout/tagout device.

- All locks will be on the "One Lock—One Key" rule. Each lock and key must be singularly identified. The supervisors shall maintain a list of locks and keys and the names of the employees to whom they have been assigned.

- Each lockout/tagout device shall be removed from each energy isolating device by the employee who applied the original lock or tag. When the authorized employee who applied the lockout or tagout device is not available to remove it, only the supervisor, accompanied by another authorized employee, may remove that device.

Lockout/tagout removal under these circumstances may be performed only when the following conditions are met.

  - The supervisor has verified that the authorized employee who applied the device is not at the facility.
  - The supervisor has made all reasonable efforts to contact the authorized employee to tell him/her that his/her lockout or tagout device has been removed.
  - The supervisor has ensured that the authorized employee is informed that his/her lockout or tagout device has been removed before the employee resumes work at this facility.

- If more than one authorized employee is required to lockout or tagout the equipment/machinery, each shall place their own personal lockout or tagout device on the energy isolating device(s).

- For shift or personnel changes during a lockout or tagout, there must be an orderly transfer of lockout or tagout devices between the first employee(s) and the relief employee(s).

- Whenever outside servicing personnel are engaged in lockout or tagout activities, the respective University department and the outside employer shall inform each other of their respective lockout/tagout procedures.

- If any laboratory employee performs lockout/tagout, training shall be given to all authorized, affected, and other personnel as follows.

  - Each authorized employee shall receive training in the recognition of applicable hazardous energy sources, type and magnitude of the energy available in their respective work places, and the method and means necessary for energy isolation and control.
  - Affected employees shall receive instructions in the purpose and use of the energy control procedures.

- All other employees who may be in areas where energy control procedures may be utilized will be informed of the lockout/tagout program, including the significance of attached tags.

- Retraining will be required whenever there is a change in lab assignments, equipment, or processes that present a new hazard, or in the energy control procedures.

- Retraining will also be required whenever the periodic inspections reflect deficiencies in an employee's knowledge or use of energy control procedures.

- Each department shall ensure that appropriate training of their employees has been accomplished and is being kept up-to-date. Training shall be documented to include the identity of persons trained and dates of training.

- All training shall be coordinated through the University EH&S office and conducted on an annual basis for those employees for whom training is necessary.