National Institutes of Health

Chemical Hygiene Plan

2019

Authored by the Division of Occupational Health and Safety (DOHS) and the Occupational Safety and Health Committee (OSHC).

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ACRONYMS

ACGIH	American Conference of Governmental Industrial Hygienists
ANSI	American National Standards Institute
BSC	Biological Safety Cabinets
CFH	Chemical Fume Hood
CFR	Code of Federal Regulations
CHO	Chemical Hygiene Officer
CHP	Chemical Hygiene Plan
DEP	Division of Environmental Protection
DOHS	Division of Occupational Health and Safety
DRS	Division of Radiation Safety
GHS	Globally Harmonized System of Classification and Labeling of Chemicals
IARC	International Agency for Research on Cancer
IC	Institutes and Centers
LEV	Local Exhaust Ventilation Systems
NIH	National Institutes of Health
NIOSH	National Institute for Occupational Safety and Health
NTP	National Toxicology Program
OMS	Occupational Medical Service
ORF	Office of Research Facilities Development and Operations
ORS	Office of Research Services
OSHA	Occupational Safety and Health Administration
OSHC	Occupational Safety and Health Committee
PEL	Permissible Exposure Limit
PI	Principal Investigator
PHS	Particularly Hazardous Substance
PPE	Personal Protective Equipment
SDS	Safety Data Sheet
TAB	Technical Assistance Branch
TLV	Threshold Limit Value published by ACGIH
TOXNET	Toxicology Data Network
TWA	Time Weighted Average

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INTRODUCTION

The use of hazardous chemicals in the laboratory is a necessary part of modern biomedical research. To ensure the protection of laboratory personnel from the risks associated with the use of hazardous chemicals, the Occupational Safety and Health Administration (OSHA) has promulgated a standard entitled *Occupational Exposures to Hazardous Chemicals in Laboratories* (29 CFR 1910.1450), referred to as the Laboratory Standard. Traditionally, OSHA health standards have been established to help protect industrial and manufacturing workers who may be exposed to significant quantities of hazardous chemicals over a working lifetime. In contrast, the use of hazardous chemicals in research laboratories is generally limited to small quantities used on a short-term basis and in operations where the chemicals and procedures change frequently. The Laboratory Standard demonstrates that OSHA has recognized the need for a standard that focuses on the unique nature of laboratory work.

The Laboratory Standard requires the development and implementation of a formal, written, and employee-accessible program, referred to as a Chemical Hygiene Plan (CHP). This plan, as defined by OSHA, must be "capable of protecting employees from health hazards associated with hazardous chemicals used in the laboratory."

The Laboratory Standard complements the provisions of the OSHA *Hazard Communication Standard* (29 CFR 1910.1200). In accordance with the *Hazard Communication Standard*, the NIH has established a written program, the *NIH Hazard Communication Program* for the use of hazardous chemicals outside of the laboratory. The NIH CHP is written specifically for the laboratory environment. Additionally, this laboratory standard supersedes the provisions of all other OSHA health standards found in 1910 Subpart Z, with the following exceptions: for the permissible exposure limits (PELs) and substance-specific limits found within the OSHA *Air Contaminants Standard* (29 CFR 1910.1000) in Subpart Z, *Toxic and Hazardous Substances* as well as the prohibition of eye and skin contact where specified by any OSHA health standard.

I. PURPOSE

This plan outlines the information and services provided by the Division of Occupational Health and Safety (DOHS), Office of Research Services (ORS) and the Division of Environmental Protection (DEP), Office of Research Facilities Development and Operations (ORF) on the safe use, storage, and disposal of hazardous chemicals in the laboratory. This program is written to meet the specific safety and health requirements outlined in 29 CFR 1910.1450, *Occupational Exposure to Hazardous Chemicals in Laboratories*.

II. SCOPE

This plan applies to all laboratories and laboratory personnel of the NIH that use, store, or handle hazardous chemicals. A hazardous chemical is defined as a substance which presents a physical hazard and/or has one or more properties for which there is statistically significant evidence that acute or chronic health effects may occur in exposed individuals. "Health effect" categories of chemicals include, but are not limited to, carcinogens, toxic or highly toxic agents, reproductive toxins, irritants, sensitizers, hepatotoxins, nephrotoxins, neurotoxins, agents which act on the hematopoietic systems and agents which damage the lungs, skin, eyes, or mucus membranes. Physical hazards include, but are not limited to, chemicals which are explosive, flammable, or corrosive. (Definition listed in **Appendix F** "Glossary of Terms.")

III. RESPONSIBILITIES

The Chemical Hygiene Officer (CHO) when requested by a laboratory representative, is responsible for assisting with obtaining Safety Data Sheets (SDSs) for hazardous chemicals, working with laboratories to determine exposure possibilities, arranging for exposure monitoring, and implementing the CHP. The CHO assists the OSHC with updating the CHP annually.

The **NIH Occupational Safety and Health Committee** (OSHC) is responsible for reviewing and evaluating the effectiveness of the CHP yearly and updating the plan as necessary.

The **DOHS Safety and Occupational Health Specialists** assist laboratory personnel in each IC in matters relating to chemical safety and exposure monitoring. Upon request, they review safety protocols for work involving hazardous chemicals to ensure that the proposed activities are conducted by trained personnel using the proper safety equipment and personal protective equipment (PPE). They conduct surveys of select laboratories to identify practices or procedures that may pose potential hazards to the health and safety of personnel.

The **Division of Occupational Health and Safety** (DOHS) conducts a number of programs focusing on laboratory safety and the proper handling of chemicals. For additional information regarding these programs contact the IC Safety Specialist, or go to the DOHS website: https://www.ors.od.nih.gov/sr/dohs/Pages/default.aspx.

The DOHS provides advice and guidance on the proper selection, use, and functioning of protective equipment. They also oversee a comprehensive testing and certification program for safety related ventilation equipment including: chemical fume hoods (CFHs), local exhaust ventilation systems (LEVs), biological safety cabinets (BSCs), and other containment systems.

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The **Occupational Medical Service** (OMS) is available to provide consultation and appropriate prophylactic or medical treatment in the case of exposure to hazardous substances. The OMS provides medical surveillance when chemical exposure monitoring data reveal an exposure at or above the action level for an OSHA regulated substance. They are also responsible for overseeing the medical monitoring of employees and retention of employee medical records.

The **Division of Environmental Protection** (DEP) **- Office of Research Facilities (**ORF) offers a number of services related to the treatment and disposal of non-radioactive waste. They provide technical support and guidance in the proper packaging, labeling and temporary storage of laboratory waste. They oversee all NIH non-radioactive chemical, medical pathological, and solid waste handling, treatment, and disposal activities, monitor NIH activities for compliance with federal, state, and local environmental regulations and the impact of those activities on the environment. They also provide guidance on the recommended use of less hazardous chemical alternatives that may still achieve the desired efficacy in specific protocols.

The **Scientific Director** (SD) of each **Institute/Center** (IC) is responsible for implementing and overseeing the CHP within their organization, which includes membership assignment of the Institute's safety committee.

The **Principal Investigator** (PI), or their designee, is responsible for chemical hygiene in the laboratory. This person is responsible for ensuring all personnel under his/her direction know and follow the CHP rules and possess the requisite knowledge, training, education and competency to handle hazardous chemicals in the laboratory in a safe and prudent manner. To demonstrate employee competency, DOHS suggests that the training be documented and include an evaluation component. A supervisor safety review checklist is provided in **Appendix K**.

Laboratory personnel are responsible for:

- Planning and conducting each operation in accordance with chemical hygiene procedures including the use of PPE, administrative and engineering controls as appropriate;
- Developing and strictly adhering to sound personal chemical hygiene habits;
- Reporting incidents and possible chemical exposures promptly to their supervisor, and;
- Correctly segregating, packaging and labeling hazardous waste for disposal according to proper procedures listed in the NIH Waste Disposal Guide.

The **Facility Manager** (ORF) provides many services related to building function and maintenance, including air pressure differential monitoring, building temperature control, and general building maintenance. Additionally, they are responsible for ensuring safe operation of equipment, such as CFHs, safety showers and eyewashes. Affected laboratory personnel will be notified prior to removal or shut down of utilities or laboratory safety equipment.

IV. TRAINING

Employees must be provided with training to ensure that they are apprised of hazards present in their work area, understand safety requirements, and PPE necessary to minimize their risk of an adverse exposure or contamination of the environment. This information must be provided at the time of initial assignment to a work area where hazardous chemicals are present and prior to assignments involving new exposure situations. Employees must be trained on the applicable details of their individual laboratory's written safety procedures. **Appendix C** outlines the requirements for employee training under the Laboratory Standard, 29 CFR 1910.1450.

DOHS provides basic safety training and information for laboratory personnel. Three training courses that address chemical hazards in the laboratory, as well as additional guidance in identifying chemicals of concern, are available. PIs are responsible for conducting or arranging appropriate hazard-specific training applicable to the processes in use.

A web-based training course, "Introduction to Laboratory Safety," covers basic laboratory safety in NIH research laboratories. This course introduces laboratory personnel to common hazards and exposure risks; including chemical, biological, radiological, and physical hazards that are found in NIH research laboratories. All laboratory personnel must complete this course upon arrival at the NIH. The web-based training program is available online.

A web-based course, "NIH Laboratory Safety Training 101" is the follow-on course to be taken after the introduction course. This course presents NIH policies and practices regarding safe conduct in NIH research laboratories, as well as further hazard recognition.

An annual web-based refresher course providing updates for safety procedures and policies that govern laboratory safety at the NIH titled "Laboratory Safety Refresher Course" is required of all NIH laboratory personnel, including summer students and summer research associates.

For additional information on laboratory safety training, please contact the DOHS at 301-496-3353 or visit the website.

V. LABELS AND SAFETY DATA SHEETS

Manufacturers are required to prepare and provide SDS for chemicals with hazardous properties. SDS for hazardous chemicals used in a work area must be readily available to employees. Many vendors have SDS online and there are a variety of subscriptions and a free collection of SDS to consult. Additional safety information should be reviewed before beginning work with a new material or a new process. The NIH Library can assist

with safety information, including TOXNET which is a valuable reference tool available through the National Library of Medicine. The DOHS is also available to assist workers with risk assessments.

Chemicals purchased from a manufacturer or distributed must be labeled properly in compliance with the Globally Harmonized System of Classification and Labeling of Chemicals (GHS). Commercial labels must state the name of the chemical, signal words, pictograms, precautionary statements and appropriate hazard statements. Bottles or any container with missing information should have additional information added without obscuring or removing any of the manufacturer's key label information. If a chemical or mixture is transferred into a different container, the name of the chemical and any associated hazards must also be placed on each new container. If a chemical is stored within a secondary container, the secondary container must also be clearly labeled with the contents and hazards.

Any laboratory prepared solutions must be labeled with the chemical identification. Containers, including beakers and flasks, left unattended must also have appropriate hazard warnings, date and the preparer's name.

If a chemical is not commercially marketed, (i.e. investigational) or is formulated in the laboratory and it is known or suspected to be hazardous, then appropriate labeling must be used and employees trained on the hazards and appropriate protective measures. If a chemical or byproduct's hazard status is unknown, it shall be assumed that the substance is hazardous. If the chemical is produced for use by others outside the producing laboratory, then the Hazard Communication Standard applies, including the requirement for labeling and preparing an SDS. Contact your IC Safety Specialist for additional guidance.

VI. CHEMICAL TRANSPORTATION

Transportation of hazardous materials and compressed gas cylinders may present risk to building occupants and property. Laboratory areas have special design features that enable proper control of these materials that may be absent when transporting materials in public corridors or on elevators.

The following shall be followed to reduce the risk of an incident during transport:

- Hazardous chemicals being transported outside the laboratory or between stockrooms and laboratories must be in break-resistant secondary containers, placed in a suitable outside container or bucket, or in carts specifically designed for safe transportation;

- Compressed gas cylinders must always be strapped in a cylinder cart with the valve protected by a cap; and

- The NIH Policy Manual 26101-42-F "Shipping Policies & Procedures," should be consulted for further reference.

VII. CONTROL OF EXPOSURE TO HAZARDOUS CHEMICALS

Hazardous chemicals may be used only in laboratory facilities specifically designed, constructed and maintained for such work. Hazardous chemicals may not be used in areas, including but not limited to, offices, storage rooms, shared equipment areas, cold rooms and other areas lacking the appropriate facilities and a proper means of ventilation.

Chemical exposures are minimized using engineering, administrative and work practice controls, in that order. Employees must wear appropriate PPE (e.g. respirator) when engineering controls are insufficient to contain the hazard or if there is an especially hazardous risk.

Engineering controls include the following:

- Chemical Fume Hoods (CFHs) and other Local Exhaust Ventilation (LEV) options such as down draft tables and slot hoods are the primary engineering methods of controlling inhalation exposures to hazardous chemicals in the laboratory. CFHs provide ventilation to carry away airborne contaminants and exhaust them outside of the building. The sash of the fume hood provides shielding to protect the user and may also provide some containment for small fires and explosions. All CFHs and LEVs used at the NIH must meet the NIH design specification. ICs may purchase CFHs only through ORF. DOHS review of any renovation affecting ventilation is required, per the NIH Design Requirements Manual (DRM).

- Any alteration affecting CFHs and LEVs or associated ductwork must be approved by DOHS prior to the system's modification. Note that meeting design specifications does NOT ensure the proper functioning of the CFH or LEV devices. The CFH must be tested yearly for proper functioning. Laboratories must work closely with DOHS and ORF to ensure safe operation of all ventilation equipment. Current ORF facility managers and contact information can be viewed online.

- Ductless CFHs are not permitted to be used in NIH laboratories. Captured organic vapors begin to desorb from the charcoal filters shortly after adsorption occurs. Some degree of breakthrough or capture failure occurs during introduction of vapor into the hood.

- Conduct all work within the CFH at a distance of at least six inches behind the face opening and position the vertical sliding sash no higher than the height

specified on the certification sticker. Avoid blocking the airfoil, baffles, and rear ventilation slot. Support large items on platforms or shelving with legs that raise the item(s) above the ventilation slot to minimize airflow disruption across the work surface.

- Minimize foot traffic around the CFH during use, since passing in front of the hood during operation disrupts the airflow and may pull contaminants out of the hood. Do not use the CFH for storage. By following these steps, the hood provides adequate containment for most chemical operations.

- CFHs equipped with alarms will alarm when the speed and volume of air moving through the hood falls outside set parameters. It is prudent to verify CFH function before each use by holding a tissue at the bottom edge of the sash and observing that the tissue flutters strongly into the cabinet. If a unit is in alarm or if the "tissue test" fails, mark the unit as "Do Not Use," and submit a work request to ORF to repair the dampers or exhaust fan. Contact DOHS to recertify the CFH prior to reuse, or if there is question about the function of the CFH.

Administrative controls include:

- Substitute a less hazardous chemical that can provide the desired results;

- Keep and consume food, beverages, cosmetics, and medication outside the laboratory;

- Keep all doors to the laboratory closed. Open laboratory doors can adversely affect CFH performance and appropriate air flow through the building;

- Ensure unimpeded access to emergency safety showers and eyewash stations. Flush eyewash stations weekly and document the date and initials of the individual who performed the test. Test emergency safety showers and eye wash showers annually and document the date and initials of the individual who performed the test. If any test of a safety device fails, submit a work request to ORF to repair the unit;

- The laboratory manager should maintain proper oversight of inexperienced personnel working with hazardous substances – see NIH Policy Manual 3015 – "Admittance of Minors to Hazardous Areas";

- Contact DOHS (301-496-2346) for clearance of the workspace when non-laboratory personnel must enter laboratories to perform required services (e.g. renovation or maintenance). Remove hazardous materials from equipment/facilities to be serviced and forewarn personnel of the need for protective equipment or work practices required. Decontaminate the equipment when possible. Ensure that repair and maintenance personnel have

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access to the appropriate personal protective equipment and have been trained in its use by their employer; and

- Do not use or store hazardous chemicals, dry ice or compressed gas in cold rooms and warm rooms due to inadequate ventilation and risk of asphyxiation.

Work Practice controls include:

- Read the SDS and become familiar with the chemical characteristics, hazards and exposure limits before using a chemical;

- Keep work area clean and uncluttered, with chemicals labeled and stored based on chemical compatibility;

- Vacuum lines shall be protected at the point of use, e.g., with an absorbent or liquid trap, to prevent entry of any material into the system. These systems are not appropriate for use with gasses, combustible, flammable or toxic materials and are designed for use with aqueous solutions only. There are special designed vacuum systems available for use with hazardous chemicals;

- Protect clothes and exposed skin by wearing laboratory coats and gowns. Open-toed shoes, sandals, shorts and other apparel that leave skin exposed are not appropriate for wear in any laboratory, especially when handling particularly hazardous substances (PHSs). Laboratory coats must not be worn outside the laboratory;

- Wear the appropriate gloves and eye/face protection whenever handling hazardous chemicals. These items must not be worn outside the laboratory;

- Remove gloves carefully and thoroughly wash hands and forearms upon completion of work and before leaving the laboratory;

- Use a certified CFH when opening, transferring, or handling volatile hazardous chemicals;

- Never pipette by mouth;

- Transport laboratory chemicals using bottle carriers and suitable carts;

- Follow the established procedures for the decontamination and safe movement of scientific and medical equipment;

- In the event of a hazardous chemical spill, immediately call 911 and follow additional procedures listed in **Appendix G**;

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- Minimize all chemical exposures and avoid underestimating the risk. Avoid unnecessary exposure to chemicals by any route of exposure;

- When diluting a concentrated acid or base, always add the acid to the water;

- Handle glassware properly and carefully. Do not use damaged glassware. Use extra care with Dewar flasks and other glass apparatuses intended for use with vacuum or pressure. Consider shielding or wrapping them to help contain chemicals and fragments should implosion or explosion occur. Use a designated container when disposing of broken glass; however, debris contaminated with chemicals shall be handled as chemical waste;

- Any hazardous operations or procedures conducted alone should be discussed and approved by the PI. If it is not possible to have someone working with you, inform someone outside the lab and ask to be checked on at regular intervals;

- If the laboratory is unattended while working with hazardous chemicals, then place an appropriate sign on the door, briefly stating the nature of the experiment, contact person and phone number. Provide for the containment of the substances in the event of failure of an engineering control such as a fume hood or utility service; and

- Do not underestimate risks. Assume that any mixture will be more hazardous than its most hazardous component and that all substances of unknown toxicity are toxic.

Contact the IC Safety Specialist at 301-496-2346 for assistance when a concern arises over potential exposure to a laboratory chemical. Specialized monitoring and chemical exposure determination is available from the DOHS.

Special Note on Medical Conditions Including Pregnancy: Individuals who have or suspect they have a medical condition, or who are pregnant or considering starting a family, and have concerns that their health could be affected by chemicals in their work area, should discuss their concerns with their supervisor, DOHS, or OMS. Note: The effects of hazardous chemicals on the reproductive system are not limited by gender.

The National Research Council publication "Prudent Practices in the Laboratory" is a thorough resource on the handling and management of chemical hazards.

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VIII. CHEMICAL STORAGE IN THE LABORATORY

The prudent selection, purchase and use of chemicals in the laboratory and the cost associated with the proper disposal of chemical wastes are inextricably linked. According to the American Chemical Society, the cost associated with chemical disposal is an average of ten times the original purchase price. Minimizing the NIH's costs and liabilities associated with of hazardous waste disposal can be achieved by adhering to the following measures:

- Order chemicals in the least amount needed to perform the work; and
- Request an assessment of your hazardous waste stream from the DEP. Both the DRS and DEP have restrictions on how to collect and label wastes. If mixing a hazardous agent with "diluent," the entire container may now be considered a hazardous waste.

Appendix D contains guidelines on the safe storage of chemicals in the laboratory.

IX. PERSONAL PROTECTIVE EQUIPMENT

Appropriate PPE is essential for worker protection and is used in combination with safe work practices and physical containment devices such as CFHs. PPE alone does not provide adequate control of hazardous chemicals but is an effective method to reduce exposure if engineering and administrative controls cannot adequately minimize the risk. The IC Safety Specialist can assist the PI or researchers in performing a Laboratory Hazard Analysis to identify hazards that are present, or likely to be present, during a particular operation. The Safety Specialist will provide information and guidance on proper engineering and administrative controls and selection and use of appropriate PPE. Information on the selection and use of PPE is also presented in the NIH Laboratory Safety training courses. **Appendix E** contains information to help choose appropriate types of PPE.

Various types of PPE, including chemical resistant gloves, lab coats, aprons, eye and face protection, etc., are available from the NIH Self Service Stores and numerous vendors. Consult the NIH Supply Catalog or call your IC Safety Specialist for additional advice (301-496-2346).

Disposable PPE that becomes visibly contaminated or is suspected of being contaminated with hazardous materials must be replaced as soon as possible. PPE contaminated with hazardous materials must be disposed of in accordance with the NIH Waste Disposal Guide.

Reference **Appendix I** for Dr. Michael Gottesman's May 2015 memorandum, titled "Laboratory Safety Responsibilities" regarding PPE expectations.

Gloves: Disposable gloves are one of the most commonly used types of PPE in the laboratory. The proper use of disposable gloves provides protection to the wearer by providing a barrier to potential hazards. Gloves also provide product protection by protecting experimental materials from enzymes or DNA on the glove wearer's hands. Select the correct glove for the task (see **Appendix E**). Certain gloves do not afford appropriate chemical protection and no single glove protects against all chemicals. All laboratory personnel are responsible for following the appropriate work practices when using disposable gloves.

- Remove your gloves carefully to avoid contacting the outside of the glove with bare skin; thoroughly wash your hands and forearms upon completion of work and before leaving the laboratory. Do not reuse disposable gloves; and

- Gloves must not be worn in common-use areas and outside laboratory rooms, outside animal holding rooms or outside procedure areas. Common areas include but are not limited to elevators, rest rooms, break rooms and corridors.

Some types of gloves are reusable. These gloves should be cleaned after each use and inspected prior to each use and replaced as necessary.

Consideration for size and comfort is important for the use of both disposable and reusable gloves. Proper size will ensure proper dexterity and maintain glove integrity while sufficient comfort will encourage continued use by the wearer.

Protective Garments: Laboratory coats or other protective garments are required to be worn when working with hazardous materials in the laboratory. This practice will help reduce exposures to hazardous materials in the laboratory by covering personal clothing and exposed skin. Remove laboratory coats before leaving the laboratory to prevent the spread of contamination outside of the laboratory.

Eye and Face Protection: Prescription safety glasses provide protection for the eyes from flying objects and are available through the OMS. Goggles and a face shield must be worn to protect the face and eyes if there is a potential for a hazardous chemical splash.

Non-prescription safety glasses may be obtained from third party vendors. Styles should be selected which fit snugly to the user's face. All eye protection must meet requirements of American National Standards Institute (ANSI) Z87.1.

Respiratory Protection: To assure workers have the correct fit and type for the hazard, respirators must not be used purchased and/or used without prior approval by the DOHS. Laboratory supervisors are not authorized to select or recommend the use of respiratory protection, regardless of the type. Dust masks and surgical masks are not appropriate for protection against chemical exposures. Special filtering face-pieces are required for chemical vapors, gases, and mists. Call your IC Safety Specialist for a consultation when

there is risk of inhalation of a chemical or particulate at your worksite. It is the policy of the NIH to provide respiratory protection at no cost to the employee when:

- The best available engineering controls fail to adequately reduce employee exposure to respiratory hazards;
- Substitution of chemicals presenting respiratory hazards with less hazardous chemicals is not feasible; or
- When modification of hazardous operations fails to reduce exposures to below acceptable levels.

The NIH abides by the OSHA Respiratory Protection Standard. The DOHS is responsible for ensuring compliance with the standard and assisting workers exposure assessments and respiratory protection. OMS provides medical clearance prior to issuance or use of a respirator. Visit the DOHS webpage on Respiratory Protection for more information or to read the Respiratory Protection Program document.

X. WORKING WITH PARTICULARLY HAZARDOUS SUBSTANCES

The PI is responsible for ensuring that appropriate precautions are taken when working with hazardous chemicals and that appropriate training is provided before working with these materials. When one or more of the following criteria is met, the PI must determine if the use of such a chemical warrants classification as a PHS. Such determination shall consider the employee exposure potential, volume of chemical used, ability to identify health effects from employee exposure, and practical use of exposure control methods.

Criteria to classify a chemical as PHS include:

- Can cause severe, acute or lethal effects upon exposure by any route in quantities of 50 µg/kg or less;
- Are highly unstable or, when combined with other compounds in the procedure, are explosive;
- May undergo chemical or physical changes during routine use and generate by-products that may overcome standard control measures or may penetrate available PPE to cause severe, acute or lethal injuries;
- Have been determined by the DOHS to present a unique hazard or are used in an operation that requires approval above the level of the laboratory supervisor;
- Carcinogens;

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- Reproductive toxins; or
- Listed as a PHS in **Appendix B**.

When a chemical is classified as a PHS, the PI shall develop a specific written Standard Operating Procedure (SOP) (which includes a Laboratory Hazard Analysis) and train potentially exposed workers prior to beginning work. This SOP should include:

- A description of the substance(s) to be used, including the potential physical and health effects;
- A step-by-step review of the work to be performed;
- A list of the available engineering controls, work practices to be utilized, and PPE;
- Designated areas for chemical use;
- Provisions for proper labeling, storage and waste disposal;
- Decontamination procedures; and
- Accident/spill procedures to include emergency contact information.

An example of a Laboratory Hazard Analysis form can be found in **Appendix J**.

XI. PRECAUTIONS REQUIRED FOR WORKING WITH PARTICULARLY HAZARDOUS SUBSTANCES

PHSs include select carcinogens, reproductive toxins and chemicals that have a high degree of acute toxicity. Substance-specific information is contained in each chemical's SDS and is also available through your IC Safety Specialist (301-496-3353). **Appendix B** contains a reference list of suggested PHSs, and those for which OSHA has specific standards. Please note that this list is not comprehensive but represents chemicals of concern that may be found in laboratories.

TAB/DOHS, together with the OMS, has established surveillance programs for certain chemicals such as formaldehyde, ethylene oxide, xylene and others. For more information contact your IC Safety Specialist.

In 2001, the "Mad as a Hatter?" campaign for a mercury-free NIH was launched. NIH Policy Manual 3033 exists to govern the "Procurement, Use, and Disposal of Mercury and Its Compounds."

Safe Work Practices with PHSs include but are not limited to the following:

- Control access to the laboratory using appropriate signs that warn of the hazards and indicate the precautions or approvals necessary for entry. Use designated areas for use and storage of PHSs. Contact your IC Safety Specialist for assistance;

- Consult the regulations, TAB/DOHS or OMS to determine if medical surveillance may be warranted if toxicologically significant quantities of PHSs are used on a routine or frequent basis;

- Contact the DEP at 301-496-7990 for assistance with specialized waste disposal;

- Keep PHSs in a secondary container to help prevent breaks and spills. The secondary container should be opened only inside a CFH;

- Attach a suitable hazard warning label to the secondary container to alert others of the chemical contained therein and the need for special precautions, for example: "Warning - Cancer Hazard" or "Highly Toxic;"

- Protect work surfaces from contamination with disposable, absorbent, plastic backed paper (plastic side down). Replace paper when contaminated or after each use and handle as hazardous waste;

- Use additional containment devices (such as shielding or protective filters) to safely handle, store or protect equipment and workers when using these chemicals;

- Wear appropriate PPE including: gloves, eye/face protection, and other protective apparel or equipment as needed. Examples include impervious gowns, aprons or gauntlets;

- Remove all protective apparel and thoroughly wash exposed skin (e.g. face, forearms, etc.) upon completion of work and before leaving the laboratory; and

- For general decontamination procedures (not to be confused with sterilization), see **Appendix H**.

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XII. MEDICAL CONSULTATION AND MEDICAL EXAMINATION

Employees who work with hazardous chemicals shall be provided the opportunity to receive medical attention when necessary. All medical examinations and consultations shall be performed by or under the direct supervision of a licensed physician and shall be at no cost to the employee and at a reasonable time and place. A written opinion shall be obtained from the physician. Specific circumstances that would enable employees who work with hazardous chemicals to receive medical attention include the following:

1. When an employee develops signs or symptoms associated with a hazardous chemical to which the employee may have been exposed in the laboratory;

2. When exposure monitoring reveals an exposure level routinely above the Action Level, or in the absence of an Action Level, the Permissible Exposure Level PEL;

3. When a substance is regulated by OSHA and requires exposure monitoring and/or medical surveillance regardless of exposure level; and

4. When an event takes place in the work area resulting in the likelihood of a hazardous exposure.

XIII. CHEMICAL HYGIENE PLAN EVALUATION AND RECORD KEEPING

The NIH CHP is reviewed annually and updated as needed by the NIH OSHC and the CHO. Comments and suggestions on the improvement of this document should be directed to DOHS (301-496-2960). See **Appendix L** for the template used during annual program evaluation and improvement.

Records for documenting laboratory safety training are maintained by the DOHS. Individuals may request their training records online or by contacting the DOHS Training Officer (301-496-3353). PIs are responsible for documenting and maintaining training records for laboratory-specific safety training. The TAB/DOHS maintains appropriate area monitoring records and OMS maintains employee medical and exposure records.

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APPENDIX A
General References

American National Standard for "Occupational Health and Safety Management Systems" ANSI/AIHA Z10-2005.

American National Standard for Occupational and Educational Eye and Face Protection Devices. ANSI/ISEA Z87.1-2010.

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Bretherick, L. Bretherick's Handbook of Reactive Chemical Hazards. 4th edition. Boston, MA: Butterworth and Company, 1990.

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APPENDIX B
Guidance for Identifying Particularly Hazardous Substances

The OSHA Laboratory Standard requires that special precautions be taken when working with substances with high acute toxicity, select carcinogens and reproductive toxins. If a PHS is used, be sure to specifically address its storage, use, disposal and possible spillage. This information should be documented, and employees trained appropriately.

Guidance set forth in this Appendix is intended to assist researchers in safely handling chemicals in the workplace. The information below does not represent a comprehensive list of chemicals of concern. For example, some investigative drugs, cytotoxic agents, or other compounds used in laboratories may have characteristics that would classify them as Particularly Hazardous Substances. For many substances in the aforementioned categories, an SDS may not be immediately available. When chemical properties are not available for an investigational substance, workers should be prudent and consider similar substances to categorize the risk and take appropriate actions to protect themselves from adverse exposures.

For more well-characterized drugs, consult the following resource: NIOSH List of Antineoplastic and Other Hazardous Drugs in Healthcare Settings, 2016. When used in a laboratory setting, drugs found on this list should be carefully evaluated to determine whether they meet the PHS definition.

The PHS List contained in this Appendix is not all-inclusive but serves as a reference of those chemicals which satisfy the criteria as a PHS. It is the responsibility of the PI to determine if the use of a chemical or drug (whether listed below or not) warrants classification as a PHS. Contact TAB/DOHS for assistance. The NIH DEP has an online database of Substances of Concern (SoC) which should also be consulted as a reference.

For specific advice or clarifications please contact TAB/DOHS, at (301) 496-3353.

Acutely Toxic Substances

Substances of high acute toxicity include materials that may be fatal or cause damage to target organs from a single exposure or from exposures of short duration. They also include materials capable of causing intense irritation that can result in pulmonary edema (fluid and swelling in the lungs), chemical asphyxia and systemic (body wide) poisoning. It is not practical to provide a list of all substances of high acute toxicity in this document. The SDS should be consulted to determine the toxicity of all substances. The TAB/DOHS, may also be consulted for additional guidance (301) 496-3353.

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Chronically Toxic Substances

Chronic effects are due to repeated exposures to low doses of toxic substances, usually over a longer period. Chronic illnesses can occur either from a build-up of a substance in the body or from an accumulation of the damage. Examples of chronically toxic substances are heavy metals such as mercury (central nervous system impairment), and organic solvents such as n-hexane (peripheral neuropathy). Chronically toxic substances also include carcinogens.

Delayed Toxicity

The effects of exposure occur after a time lapse. Carcinogenic effects of exposure may have long latency periods, often 20 to 30 years after the initial exposure, before tumors are observed in humans.

Hypersensitivity

Chemical allergens can cause an adverse, antibody-mediated reaction that can result in sensitization to a chemical. As with environmental allergens such as pollen and animal dander, not everyone's immune system will become sensitized to any particular chemical. For those who develop a chemical allergy, sensitization usually evolves over time, after which even a low dose exposure to the chemical results in an allergic reaction. The reaction itself requires prior exposure and can range in severity from minor skin disturbances such as inflammation, itching, and redness, to life-threatening anaphylaxis.

Although any compound possesses the potential to elicit an allergic response in some subpopulation of workers, there are some chemicals that induce sensitization more commonly than others. Some common allergens include toluene diisocyanate, beryllium, methyl methacrylate, formaldehyde, dinitrochlorobenzene and powdered vinyl and latex gloves.

Reproductive Toxins

Reproductive toxins are agents that affect reproductive capabilities including chromosomal damage (mutations) and produce effects on developing fetuses (teratogenesis). Reproductive toxins can affect both men and women. Examples of adverse reproductive health effects include birth defects, spontaneous abortion, fetal developmental damage, and infertility. It is important to note that the first trimester of pregnancy is the period of most concern to the developing fetus because this is when the organs and the limbs are being formed. During this period, many women may not yet be aware that they are pregnant. For this reason, it is important that the use of reproductive toxins have been identified and that control measures are in place to protect a woman and her fetus from harmful exposure levels. Women who are (or are trying to become) pregnant may consult with OMS before the start of any laboratory or shop activity involving reproductive toxins.

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Carcinogens

Carcinogens are agents that cause neoplasms (tumors) in humans and/or animals. Carcinogenic agents may be organic chemicals, inorganic chemicals, or hormones. Some carcinogens react directly with a cell's genetic information (the DNA), causing changes (mutations) that are incorporated into subsequent generations of that cell. Select carcinogens are agents that are strongly implicated as sources of cancer in humans.
A select carcinogen is any substance which meets one of the following criteria:

- It is regulated by OSHA as a carcinogen;
- It is listed under the category "Known to be carcinogens" in the Annual Report on Carcinogens published by the National Toxicology Program (NTP);
- It is listed under Group 1 "Carcinogenic to humans by the International Agency for Research (IARC) Cancer Monographs"; or
- It is listed in either Group 2A or 2B by IARC or under the category "Reasonably anticipated to be carcinogens" by NTP.

If you work with any of the OSHA-regulated chemicals, you need to be aware of and comply with the specific OSHA standards governing their use. OSHA has established standards that are above those required by under the "Occupational exposure to hazardous chemicals in laboratories" standard. In some cases, the chemical specific standard may require special signs, medical surveillance and routine air monitoring of your workplace. If you use these chemicals routinely, even for short periods of time, contact DOHS for a review to assure that your work practices and engineering controls are sufficient to keep your exposures below the OSHA specified limits. A listing of the chemical standards is available online.

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Particularly Hazardous Substance List

Chemicals with Acute Toxicity*

Aniline [62-53-3]
Cyanide salts [592-01-8]
Dimethylmercury [593-74-8]
Hydrofluoric acid [7664-39-3]

Compressed Gases with Acute Toxicity

Arsine [7784-42-1]
Boron trifluoride [7637-07-2]
Hydrogen peroxide [7722-84-1]
Methylamine [74-89-5]
Ozone [10028-15-6]
Phosgene [75-44-5]
Phosphine [7803-51-2]
Hydrogen cyanide [74-90-8]
Hydrogen fluoride [7664-39-3]
Chlorine [7782-50-5]
Fluorine [7782-41-4]
Hydrogen bromide [10035-10-6]
Hydrogen chloride [7647-01-0]

OSHA Carcinogens

4-Nitrodiphenyl [92-93-3]
alpha-Naphthylamine [134-32-7]
Chloromethyl methyl ether [107-30-2]
3,3'-Dichlorobenzidine [91-94-1]
Bis(chloromethyl)ether [542-88-1]
beta-Naphthylamine [91-59-8]
Benzidine [92-87-5]
4-Aminodiphenyl [92-67-1]
Cadmium [7440-43-9]
Ethylenimine [151-56-4]
beta-Propiolactone [57-57-8]
2-Acetylaminofluorene [53-96-3]
4-Dimethylamino-azobenezene [60-11-7]
N-Nitrosodimethylamine [62-75-9]
Benzene [71-43-2]
Formaldehyde [50-00-0]
1,3, Butadiene [106-99-0]
1,2-Dibromo-3-chloropropone [96-12-8]

Reproductive Toxins

Formamide [75-12-7]
Lead compounds
Organic mercury compounds

* The ANSI Z129.1 classification as a "highly toxic chemical" includes chemicals in any of the following categories:

1) A chemical that has a median lethal dose (LD50) of 50 milligrams or less per kilogram of body weight when administered orally into albino rats weighing between 200 and 300 grams each, or

2) A chemical that has a median lethal dose (LD50) of 200 milligrams or less per kilogram of a chemical that has a median lethal dose (LD50) of 200 milligrams or less per kilogram body weight when administered by continuous contact for 24 hours (or less, if death occurs within 24 hours) with the bare skin of albino rabbits weighing between two and three kilograms each, or

3) A chemical that has a median lethal concentration (LC50) in air of 200 parts per million by volume or less of a gas or vapor, or 2 milligrams per liter of mist, fume, or dust, when administered by continuous inhalation for one hour (or less, if death occurs within one hour) to albino rats weighing between 200 and 300 grams each, provided such concentrations and/or conditions are likely to be encountered in a reasonably foreseeable manner.

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PHS Requirements:

- PIs are responsible for identifying PHSs used in the work area. Review sources such as SDSs for specific compounds; and

- An assessment of the hazards and controls in place is necessary to limit employee exposures to these agents. Contact your IC Safety Specialist for assistance.

OSHA requires that the following four categories of controls be considered for operations and activities involving PHSs:

- Establish posted designated areas. A designated area may be a room, a section of a room, a bench top or a containment device (such as a laboratory hood). Requirements may be found in the section entitled "Designated Areas." NOTE: When handling substances (in non-laboratory settings) that are regulated by OSHA substance specific standards (such as asbestos), "regulated areas" will be established in accordance with the applicable OSHA standard;

- Use containment devices (such as CFHs, downdraft tables, LEVs, gas cabinets, glove boxes or the equivalent);

- Implement contaminated waste removal procedures; and

- Establish decontamination procedures. These are necessary to prevent the spread of contamination to other areas. Decontamination procedures include practicing good housekeeping by wiping down work surfaces at the end of the day and cleaning up drips, residues, and spills. Cleanup materials used (such as absorbents and cloths) must be disposed of as hazardous waste.

The following controls are required for PHSs:

Training and Information

- Employees who either handle or who may be exposed to PHSs must complete "Laboratory Safety" training;

- All employees who may be exposed to PHSs must be trained in the specific hazards and controls of the materials being handled. Furthermore, employees working in designated areas are to be informed of the specific hazards and controls of the materials used. Area-specific training is a line management responsibility. The TAB/DOHS, is available to provide assistance;

- Consult the section entitled "Labeling and Safety Data Sheets" for labeling requirements for primary and secondary containers; and

- The designated areas of PHS use must be posted with a caution sign depicting hazards and emergency contact information.

Substitution and Chemical Inventory Management

- Identify and use safer chemical alternatives if possible;
- If a safer chemical cannot be used, limit what purchases or borrow the necessary quantity from a colleague;
- Conduct periodic cleanouts to prevent accumulating unneeded chemicals; and
- Procure and use the minimum amount of material required for the operation.

Ventilation

- Use LEVs such as a CFH or glove box when handling PHSs in a manner that may produce an airborne hazard (such as fumes, gases, vapors and mists). This includes transfer operations, preparation of mixtures, blending, sonication, spraying, heating and distilling. See Engineering Controls for more information.

Work Practices

- Transfer containers in bottle carriers;
- Do not eat, drink, smoke, chew gum or tobacco, store food, beverages and products of personal consumption such as health and beauty aids in work areas where PHSs are being used or stored;
- Use a mechanical aid or a pipette bulb for pipetting;
- Open bottles or carboys slowly and carefully and wear PPE to protect from splashes and vapors/gases;
- Wipe drips/residues from containers and work surfaces. To facilitate decontamination, use stainless steel or plastic trays, absorbent paper with a moisture-proof lining, or other impervious material;
- Upon completion of the operation, decontaminate or discard the protective covering material as hazardous waste;
- Wash hands before leaving the work area and prior to consuming food/beverages.

Personal Protective Equipment

Skin and eye contact with PHSs shall be prevented. The following PPE must be worn when handling these materials**:**

- At a minimum, safety glasses with side shields, laboratory coats (coveralls are acceptable in shop settings) and closed-toe shoes will be worn when handling these materials. These measures are considered to be minimum protection and must be upgraded if necessary;

- Additional PPE such as chemical goggles, face shields, chemical aprons, disposable coveralls, chemically resistant gloves, and respiratory protection must be worn if there is a greater chance of chemical exposure. An IC Safety Specialist may be contacted for assistance in selecting appropriate gloves and respiratory protection. The use of respiratory protection requires an industrial hygiene hazard evaluation and a medical clearance followed by a fit test and training by TAB/ DOHS;

- Consult "Eye and Face Protection" in the PPE Section for guidance on the selection, uses, and limitations of safety glasses, chemical goggles and face shields;

- Since many chemicals are skin-absorbents (i.e., agents that readily pass through the skin), it is important to select gloves that are chemically resistant to the material. Consult the PPE section, which contains a list of skin-absorbent agents and provides detailed guidance for selecting chemically resistant gloves. An IC Safety Specialist may also be contacted for assistance in selecting appropriate gloves; and

- Gloves must be selected based on their chemical resistance to the material(s) being handled, their suitability for the procedures being conducted, and their resistance to wear, as well as temperature extremes. Improper selection may result in glove degradation, permeation of the chemical through the glove and ultimately, personal exposure to the chemical. This is a potentially serious situation. Consult "Gloves" in **Appendix E** for guidance on the selection, uses, limitations and disposal of chemically resistant gloves. An IC Safety Specialist may also be contacted for assistance in selecting appropriate gloves.

Additional information may be found in **Section IX.**

Storage

Consult **Appendix D** for storage information regarding hazardous chemical incompatibility.

Emergency Procedures

Refer to **Appendix G** for response procedures for chemical spills and personal exposure to chemicals.

APPENDIX C
Employee Training and Information

Information that must be provided to employees:

- The contents of the 29 CFR 1910.1450 standard and its appendices;
- The location and availability of the NIH CHP;
- The PELs for OSHA-regulated substances and recommended exposure limits for other hazardous chemicals where there are no applicable OSHA standards;
- Signs and symptoms associated with exposures to hazardous chemicals used in the lab;
- The location and availability of known reference material on the hazards, safe handling, storage and disposal of hazardous chemicals found in the laboratory including, but not limited to, SDSs received from the chemical supplier;
- The appropriate PPE. Employees should be instructed on the proper wear, use, maintenance, and limitations; and
- Safety operating procedures developed for PHSs.

Employee training should be documented and shall include:

- Methods and observations that may be used to detect the presence or release of a hazardous chemical (such as monitoring conducted by the employer, continuous monitoring devices, visual appearance or order of hazardous chemicals when being released, etc.);
- The physical and health hazards of chemicals in the work areas;
- The measures employees can take to protect themselves from these hazards, including specific procedures the employer has implemented to protect employees from exposure to hazardous chemicals, such as appropriate work practices, emergency procedures, and PPE to be used;
- Applicable details of the NIH CHP; and
- Retraining identified as appropriate.

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APPENDIX D
Proper Storage of Chemicals in the Lab

Considerations for proper storage:

- Ensure all containers of hazardous chemicals are properly labeled with the identity of the hazardous chemical(s) and appropriate hazard warnings;
- Record the date of receipt on each chemical to assist with inventory management;
- Record the date of opening on each peroxide former and dispose or test for peroxides as directed (see **Appendix D, Table 2** for more information);
- Solutions must be labeled and dated when prepared with a commonly known name of the hazard or mixture and any applicable hazard warnings;
- Segregate all incompatible chemicals for proper storage by hazard class. In other words, store like chemicals together and away from other groups of chemicals that might cause reactions if mixed;
- Only store chemicals alphabetically within each group of compatible chemicals;
- Flammable and combustible materials must be stored in an approved storage cabinet. Keep cabinet doors closed;
- Hazardous chemicals should be stored no higher than eye level and never on the top shelf of a storage unit. Do not overcrowd shelves. Each shelf should have an anti-roll lip;
- Avoid storing chemicals on the floor (even temporarily) or extending into aisles;
- Liquids should be stored in unbreakable or double-contained packaging, or the storage cabinet tray should have the capacity to hold the contents if the container breaks or leaks;
- Store acids in a dedicated acid cabinet. Nitric acid, sulfuric acid, perchloric acid and chromic acid are strong oxidizers. They may be stored in the same acid cabinet only if they are kept isolated from all other acids;
- CFHs shall not be used for storage as containers block proper air flow, reduce available work space, and exacerbate hazards in case of fire or spill;
- Chemicals to be stored in a refrigerator or freezer must be in appropriately rated hazardous material storage units;

- Do not store hazardous chemicals in a cold room or other storage area with recirculating ventilation;

- Do not store chemicals under a sink, except for water-soluble cleaning solutions;

- Only compressed gas cylinders that are in use and secured in place shall be kept in the laboratory. All others, including empties, shall be sent to the compressed gas cylinder storage area for the facility;

- Keep all stored chemicals, especially flammable liquids, away from heat and direct sunlight; and

- Periodically inspect stored chemicals to verify container integrity.

Safety Hints:

- Do not purchase hazardous chemicals in quantities greater than can be used in 6 months or within the specified storage period;

- Ethers and other peroxide formers should be stored in the dark;

- Some materials are more stable when stored under an inert gas such as nitrogen. See the manufacturers information/SDS for guidance;

- Always check for the presence of peroxides before distilling any peroxide-former;

- Consult safety references (SDSs) before working with hazards which are new, using hazards in new processes, or if any are hazards are unfamiliar;

- If old containers of peroxide-forming chemicals are found, do not move them. Contact the DEP for assistance in disposing of the container;

- Follow the disposal guidelines provided by the NIH Waste Disposal Guide. Do not dispose of chemicals down the drain or by evaporation. Questions regarding what may be approved for drain disposal may be directed to the DEP at (301) 496-3537;

- Properly collect, tag and date waste. Keep chemical waste containers closed/sealed. Use secondary containment under waste collection containers to prevent spills; and

- Refer to the EPA's chemical compatibility chart before mixing chemical wastes.

Table 1. Chemical Segregation and Storage Chart

Always consult the SDS

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The Chemical Segregation and Storage Chart begins on the next page.

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Table 1. Chemical Segregation and Storage Chart

Chemical Segregation

Class of Chemicals	Common Chemical	Additional Concerns and Storage Recommendations	Common Incompatible Chemicals	Possible Reaction if Mixed/Health Concerns
Corrosive Acids-Organic	Acetic Acid Glacial Acetic Acid Butyric Acid Trifluoroacetic Acid Picric Acid Propionic acid	Store in ventilated corrosives cabinet on protected shelving using secondary containment, keep away from water sources *Do not store under the sink *Do not store acids on metal shelving	Flammable Liquids Flammable solids Bases Oxidizers Inorganic acids Cyanides Sulfides Poisons/toxins	Heat Gas Generation Violent Reaction * DO NOT POUR WATER INTO ACID
Corrosive Acids-Inorganic	Nitric Acid Sulfuric Acid Perchloric Acid Phosphoric Acid Hydrochloric Acid Chromic Acid Formic Acid	Store concentrated Nitric Acid (≥68%) and Sulfuric Acid (≥93%) in a secondary container Store in a corrosive cabinet labeled "Acid", or on shelving using a secondary containment *Do not store under the sink *Do not store acids on metal shelving	Flammable liquids Flammable solids Bases Oxidizers Organic acids Cyanides Sulfides Poisons/toxins	Heat Gas Generation Violent Reaction *DO NOT POUR WATER INTO ACID *Perchloric Acid vapor can form explosive compounds within fume hood ducts.
Corrosive Bases-Organic/Caustic	Hydroxylamine Tetramethylethylamine Diamine Triethylamine	Separate cabinet preferably with ventilation, corrosive cabinet or storage area with a spill tray, away from potential water sources (Do not store under sinks or near water sources)	Acids Oxidizers Flammable liquids Flammable solids Inorganic bases Poisons/toxins	Heat Gas Generation Violent Reaction
Corrosive Bases-Inorganic/Caustics	Ammonium Hydroxide, Potassium Hydroxide, Sodium Hydroxide, Calcium Hydroxide	Separate cabinet preferably with ventilation, corrosive cabinet or storage area with a spill tray, away from potential water sources (NOT under the sink); Store solutions of inorganic hydroxides in labeled polyethylene containers.	Acids Oxidizers Flammable liquids Flammable solids Organic bases Poisons/toxins	Heat Gas Generation Violent Reaction
Flammable Solids	Charcoal Carbon Paraformaldehyde Phosphorus Magnesium Ethyl Acetate	Keep in a dry, cool area away from oxidizers and corrosives	Acids Bases Oxidizers Poisons/toxics	Fire Hazard Violent Reaction

Chemical Segregation

Class of Chemicals	Common Chemical	Additional Concerns and Storage Recommendations	Common Incompatible Chemicals	Possible Reaction if Mixed/Health Concerns
Flammable Liquids	Ethanol, Methanol Acetone, Benzene Xylene, Toluene Diethyl Ether Tetrahydrofuran Acetonitrile Glacial Acetic Acid Acetone Liquids with flashpoints < 100 F	Flammable storage cabinet or refrigerator rated for flammable/ hazardous storage/explosion proof *Peroxide-forming chemicals must be dated upon delivery and opening (two dates).	Oxidizers Acids Bases Reactives Poisons/toxins	Fire Hazard Heat Violet Reaction
Toxins	Chloroform Cyanides Heavy Metal Compounds (e.g. Cadmium, Mercury, Osmium, Oxalic acid, Phenol, Formic acid), Formamide, Carbon Tetracholride, 2-Mercaptoethanol Phenol, *Hydrofluoric Acid - Hydrofluoric Acid is a Highly Acute Toxin	Store in a dark dry, ventilated cool area in a chemically resistant secondary container (polyethylene or polypropylene) *Hydrofluoric Acid should be stored in an area accessible only by authorized personnel; do not store in glass; use plastic containers and secondary containment	Flammable liquids Acids Bases Reactives Oxidizers Please consult Division of Environmental Protection (DEP) for assistance * Hydrofluoric Acid: All organic acids (e.g. Acetic Acid), Bismuthic Acid, Chlorosulfonic Acid Methanesulfonic Acid Nitric Acid Perchloric Acid Sulfuric Acid	Generation of Toxic and Flammable gas Combustible Heat Fire Hazard Explosion Hazard Violent Reaction Chloroform explosively reacts with chemically-reactive metals (e.g., aluminum or magnesium powder, sodium, and lithium), strong oxidizers, strong caustics (e.g., alkalis), and decomposes in sunlight *Hydrofluoric Acid, can result in relatively small burns from this acid can be lethal
Poisons	Cadmium Cyanides Mercury Osmium Acrylamide Ethidium Bromide Sodium Azide	Store in a vented, cool, dry area in unbreakable chemically resistant secondary containers * Store volatile poisons with evaporation rate above 1.0 - (ether =1.0) in flammable cabinet; Store non-volatile liquid poisons in a refrigerator or cabinet; amounts less than 1 liter can be stored in a cabinet above bench level if the cabinet has sliding doors not swinging.	Flammable liquids Acids Bases Oxidizers Corrosives Please consult the DEP-Division of Environmental Protection for assistance	Generation of Toxic and Flammable gas Violent Reaction
Explosives	Picric Acid Ammonium Nitrate Nitro Urea Trinitroaniline Benzoyl Peroxide Trinitrobenzene Trinitrobenzoic Acid Trinitrotoluene Urea Nitrate Trinitrophenol Diazoisbutylnitrile	Store in a secure location away from other chemicals; store in an area away from friction or shock	Please consult the SDS and the DEP	Explosion Hazard Violent reaction Heat Shock Friction

Chemical Segregation

Class of Chemicals	Common Chemical	Additional Concerns and Storage Recommendations	Common Incompatible Chemicals	Possible Reaction if Mixed/Health Concerns
Oxidizers	Peroxides, Nitrates, Perchlorates Permanganates Sodium Hypochlorite Ethyl Acetate, Iodine, Benzoyl Peroxide Potassium Dichromate Chlorates, Bromates, and Superoxides Ammonium Persulfate, Ferric chloride	Store in secondary containment separately from combustibles and flammable materials	Combustibles Flammables Organic materials Reducing Agents	Fire Hazard Gas Generation Toxic Gas
Peroxide Formers	Acrylonitrile Isopropyl alcohol Ethers (e.g. diethyl ether, isopropyl ether) Acetals and ketals, especially cyclic ethers and those with primary and/or secondary Alkyl groups Aldehydes (e.g. acetaldehyde, benzaldehyde) Vinyl and vinylidene compounds, Dienes Tetrahydrofuran Dioxane Butylated Hydroxytoluene (BHT) Isopropyl Ether	Store in airtight bottles, away from light and heat in a dark, cool dry area; see Table 3 for recommended storage time limits; avoid using containers with loose-fitting lids and ground glass stoppers; crystallization, discoloration, and formation or deposition of layers are signs a peroxide former may have become shock sensitive; do not use or move such containers: contact DEP; all bottles of peroxide-forming chemicals must have the received date marked on the container; when the bottle is first opened, the container must be marked with the date opened.	Always consult the Safety Data Sheet (SDS) and the Division of Environmental Protection (DEP)	Explosion Hazard Violent Reaction Shock sensitive Combustion (Exothermic reaction)
Water Reactive	Sodium metals Lithium metals Potassium metals Sodium Borohydride Lithium Aluminum Hydride	Store in a dry, cool area away from potential spray from fire sprinklers and other water sources (DO NOT store under the sink) Label this area for water-reactive storage	Aqueous solutions Oxidizers Please consult the Safety Data Sheet (SDS) and the Division of Environmental Protection (DEP)	Heat Violent Reaction

Chemical Segregation

Class of Chemicals	Common Chemical	Additional Concerns and Storage Recommendations	Common Incompatible Chemicals	Possible Reaction if Mixed/Health Concerns
Flammable Compressed Gases	Methane Acetylene Butane Propane Hydrogen Silane Ethane Arsine Germane	Store in cool, dry area away from oxidizing gases while gases are securely attached to wall or bench	Oxidizing solids Oxidizing & toxic compressed gases	Fire Hazard Explosion Hazard
Oxidizing Compressed Gases	Oxygen Chlorine Fluorine Nitrogen Oxides Gases containing oxygen at higher than atmospheric concentrations (above 23-25 percent)	Store in cool, dry area away from flammable gases and liquids while gases are securely attached to wall or bench	Flammable gases	Fire Hazard Explosion Hazard
Poisonous Compressed Gases	Carbon Monoxide Hydrogen Chloride Hydrogen Sulfide Nitrogen Dioxide	Store in cool, dry area away from flammable gases and liquids while gases are securely attached to a wall or bench	Flammable gases Oxidizing gases	Release of Toxic Gas Violent Reaction
Strong Reducing Agents	Acetyl chloride Thionyl chloride Maleic anhydride Ferrous sulfide	Store in cool, dry, well-ventilated location Water reactive Segregate from all other chemicals	Please consult the specific SDS and DEP	Please consult the specific SDS and DEP

Chemical Segregation

Class of Chemicals	Common Chemical	Additional Concerns and Storage Recommendations	Common Incompatible Chemicals	Possible Reaction if Mixed/Health Concerns
Carcinogens	Benzidine Beta-naphthylamine Benzene Methylene chloride Beta-propiolactone Carbon Tetrachloride	Label all containers as "Cancer Suspect Agents" or the equivalent. Store according to the hazardous nature of the chemical, using appropriate security when necessary	Please consult the specific SDS and DEP	Please consult the specific SDS and DEP
Teratogens	Lead compounds Mercury compounds Benzene Aniline	Label all containers as "Suspect Reproductive Hazard" or "Reproductive Effecter" Store according to the hazardous nature of the chemical, using appropriate security when necessary	Aniline incompatible with Nitric Acid and Hydrogen Peroxide Please consult the specific SDS and DEP	Please consult the specific SDS and DEP
General Stock Chemicals	Sodium bicarbonate Sodium chloride Agar Salt buffer Most non-reactive salts	Store on shelves, or laboratory benches or shelving preferably behind glass doors and below eye level with like chemicals	Please consult the SDS and DEP	Please consult the specific SDS and DEP

If an old or expired container of a peroxide-forming chemical or reactive is found, do not move it. Contact DEP at 301-496-4710 for assistance in disposing of the container. Adapted from Prudent Practices in the Laboratory: Handling and Disposal of Chemicals, National Research Council, 1995, University of Texas/Health Science at Houston and Boston University Environmental Health & Safety.

Table 2. Suggested Storage Time Limits for Common Peroxide Forming Compounds

Under proper conditions, these chemicals will form explosive peroxides which can be detonated by shock or heat. Follow manufacturer's storage time limits and expiration date. Although storage under inert gas or with a stabilizer may prolong shelf-life, test the container for peroxides before use beyond the expiration date or before any possible distillation procedure.

MOST DANGEROUS: Discard after 3 months. Peroxide formation hazard during storage.	
Diisopropyl ether Divinyl acetylene Potassium metal	Sodium amide Vinylidene chloride

DANGEROUS: Discard after one year. Peroxide formation hazard during storage and on concentration (i.e., distillation) of compound.		
Acetal Acetaldehyde Cumene Cyclohexene Diacetylene	Dicyclopentadiene Diethyl ether 1,4-Dioxane Ethylene glycol dimethyl ether Methyl acetylene	Methyl cyclopentane Methyl isobutyl ketone Tetrahydrofuran Tetrahydronaphthalene Vinyl ethers

DANGEROUS: Discard after one year. Peroxide formation causes initiation of hazardous polymerization.		
Acrylic acid Acrylonitrile 1,3-Butadiene 2-Butanol	Chloroprene Chlorotrifluoroethylene Methyl methacrylate 2-Propanol Styrene	Tetrafluoroethylene Vinyl acetate Vinyl acetylene Vinyl chloride Vinyl pyridine

Adapted from *Prudent Practices in the Laboratory: Handling and Disposal of Chemicals*, National Research Council, 1995.

This list is illustrative, not comprehensive. Check the SDS of your chemical to determine if it forms peroxides. If so, there will be a warning under the heading *Precautionary Labeling or Fire* and *Explosion Hazard Data* on the SDS. If a substance does not appear on the lists and the SDS does not indicate that it is a peroxide former, but you suspect that it is a peroxide former, evaluate the molecular structure of the chemical for peroxide forming functional groups and the chemical families of peroxide formers below:

ORGANIC

A. Ethers, acetals
B. Olefins with allylic hydrogens, chloro- and fluoro-olefins, terpenes
C. Dienes, vinyl acetylenes
D. Aldehydes
E. Ureas, amides, lactams
F. Vinyl monomers including vinyl halides, acrylates, methacrylates, vinyl esters

INORGANIC

A. Alkali metals, particularly potassium
B. Alkali metal alkoxides and amides
C. Organometallics

APPENDIX E
Selection of PPE

Lab Coat Selection Information

- Fabric weight and weave affect how easily material ignites and burns. Select tight weave, heavy weight, and tightly-fitted sleeves/cuffs for work with flammables and pyrophorics;
- Launder or replace weekly (or earlier if contaminated). Use commercial laundry only;
- Cuffed sleeves keep wrists covered and help prevent dipping sleeve in work;
- Closeable lapel is preferred for maximum coverage from hazards;
- Consider sturdy chemical-resistant aprons for high-hazard work such as with pyrophorics, flammables, corrosives, etc.;
- Most synthetics resist ignition but once ignited will melt and can cause severe localized burns; and
- Blended fabrics often have a high rate of burning combined with fabric melting but are often most comfortable to wear and economical.

FABRIC TYPE	USES	CAUTION
Polyethylene	Liquid resistant for high-hazard biological materials such as BSL3, or if splash or large volume	Do not use with flammables or pyrophorics
Cotton	All-purpose	Heavy weight and weave preferred, liquids absorb
Polypropylene disposable	General bench work	Do not use with flammables or pyrophorics
Cotton/poly blend	General bench work	Do not use with flammables or pyrophorics
Fire-retardant	Pyrophoric or highly flammable materials	May need special laundering, wash and replace per manufacturer instruction
Neoprene apron and sleeves	Solvents, corrosives	Clean and dry to allow re-use, replace when damaged
Tyvek® Spunbond olefin	Biological or particulate, clean rooms	Variable chemical resistance, consider Tychem® for heavy chemical contact

Glove Selection Information

- All gloves are permeable, and the resulting changes are not always visible;
- Visible degradation can include swelling, softening, hardening and discoloration;
- Different gloves are resistant to different chemicals;
- Multiple gloves can be worn together for greater protection (use smallest size that will fit comfortably for dexterity purposes);
- Reusable gloves can be used for intermittent chemical work in the lab, but care must be taken to properly rinse and air dry and they must be inspected before each use;
- Disposable gloves provide barrier protection for small amounts of lab chemicals but need to be immediately replaced when they become contaminated and should never be reused;
- Latex deteriorates with petroleum products;
- Surgical latex gloves are thicker than latex exam gloves; and
- Always consult manufacturer's glove selection guidelines for specific hazards.

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Glove Selection Guide (unsupported)

GLOVE TYPE	USES	CAUTION
Disposable: vinyl, latex, nitrile	Dry Powders Aqueous Solutions	*Do **NOT** use for solvents and corrosives *Disposable gloves must be replaced immediately upon chemical contamination
Reusable: Neoprene (Black)	Corrosives, solvents and alcohols Resists oils and offers less fatigue	Must be properly rinsed and dried after each use
Reusable: Nitrile (Blue or Green)	Organic solvents (non-halogenated) Puncture and abrasion resistant	Must be properly rinsed and dried after each use
Reusable: Nomex or Zetex	Temperature extremes	*Do **NOT** use for Asbestos *Must be properly rinsed and dried after each use
Reusable: Butyl	Aldehydes, ketones and esters	Must be properly rinsed and dried after each use
Reusable: Viton TM	Chlorinated and aromatic solvents	Must be properly rinsed and dried after each use

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APPENDIX F
Glossary of Terms

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

Antineoplastic: Blocking the formation of neoplasms (growths that may become cancer).

Antineoplastic Antibiotic: A type of anticancer drug that blocks cell growth by interfering with DNA, the genetic material in cells. Also called anticancer antibiotic and antitumor antibiotic.

Chemical Hygiene Officer: A qualified individual who provides technical guidance in developing and implementing a CHP.

Chemical Hygiene Plan: A written program developed and implemented by the employer which sets forth procedures, equipment, personal protective equipment and work practices that are capable of protecting employees from the health hazards presented by hazardous chemicals used in that particular workplace.

Combustible liquid: Any liquid having a flashpoint at or above 100ºF (37.8ºC), but below 200ºF (93.3ºC), except any mixture having components with flashpoints of 200ºF (93.3ºC) or higher, the total volume of which makes up 99% or more of the total volume of the mixture.

Corrosives: Materials that cause destruction on contact with living tissue. Precautions for corrosives focus mainly on preventing such contact. Acids with a pH<2 and bases with a pH>12 are especially dangerous. Eye protection that forms a complete seal around the eyes (goggles) and appropriate gloves must always be used when handling corrosive materials. A face shield over safety glasses, a rubber apron and rubber boots may also be appropriate. An eyewash and safety shower must be readily accessible in areas where corrosives are used and stored.

Cytotoxic agent: A substance that kills cells, including cancer cells. These agents may stop cancer cells from dividing and growing and may cause tumors to shrink in size.

Designated Area: A predetermined and well-labeled area in which carcinogens, reproductive toxins (teratogens/embryotoxins), or other chemicals with significant acute or chronic toxicity are used/kept in the laboratory.

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

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

Flammable: A chemical that falls into one of the following categories:

- **Aerosol, flammable** – an aerosol that, when tested by the method described in 16 CFR 1500.45, yields a flame protection exceeding 18 inches at full valve opening, or a flashback (a flame extending back to the valve) at any degree of valve opening.

- **Gas, flammable** – a gas that,

  - at ambient temperature and pressure, forms a flammable mixture with air at a concentration of 13% by volume or less; or

  - at ambient temperature and pressure, forms a range of flammable mixtures with air wider than 12% by volume, regardless of the lower limit.

- **Liquid, flammable** – any liquid having a flashpoint below 100ºF (37.8ºC), except any mixture having components with flashpoints of 100ºC or higher, the total of which make up 99% or more of the total volume of the mixture.

- **Solid, flammable** – a solid, other than a blasting agent or explosive that is liable to cause fire through friction, absorption of moisture, spontaneous chemical change, or retained heat from manufacturing or processing, or which can be ignited readily and when ignited burns so vigorously and persistently as to create a serious hazard. A chemical shall be considered to be a flammable solid if, when tested by the method described in 16 CFR 1500.44, it ignites and burns with a self-sustained flame at a rate greater than 1/10" per second along its major access.

Flashpoint: The minimum temperature at which a liquid gives off a vapor in sufficient concentration to ignite when tested as follows:

- Tagliabue Closed Tester (American National Standard Test Method (ASTM D 56-79)) for liquids with a viscosity of less than 45 Saybolt Universal Seconds at 100ºF (37.8ºC) that do not contain suspended solids and do not have a tendency to form a surface film under test; or

- Pensky-Martens Closed Tester (American National Standard Method (ASTM D 93-79)) for liquids with viscosity equal to or greater than 45 SUS at 100ºF (37.8º C), or that contain suspended solids, or that have a tendency to form a surface film under test; or

- Setaflash Closed Tester (American National Standard Method (ASTM D 3278-78)).

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*Organic peroxides, which undergo auto-accelerating thermal decomposition, are excluded from any of the flashpoint determination methods specified above.

Hazardous Chemical: A substance which presents a physical hazard and/or has one or more properties for which there is statistically significant evidence that acute or chronic health effects may occur in exposed individuals. "Health effect" categories of chemicals include, but are not limited to, carcinogens, toxic or highly toxic agents, reproductive toxins, irritants, sensitizers, hepatotoxins, nephrotoxins, neurotoxins, agents which act on the hematopoietic systems and agents which damage the lungs, skin, eyes, or mucus membranes. Physical hazards include, but are not limited to, chemicals which are explosive, flammable, or corrosive.

Hazardous Drug: A drug that is approved for use in humans by the FDA; is not otherwise regulated by the U.S. Nuclear Regulatory Commission; and either a) is accompanied by prescribing information in the "package insert" that includes special handling information to protect workers handling the drug, or b) exhibits one or more of the following types of toxicity in humans, animal models, or *in vitro* systems: carcinogenicity; teratogenicity or other developmental toxicity; reproductive toxicity; organ toxicity at low does; genotoxicity; or structure and toxicity profile that mimics existing drugs determined hazardous by exhibiting any one of the previous five toxicity types.

Highly Toxic: A substance with a lethal dose (LD) or lethal concentration within the following limits. Oral: LD50< 50 mg/kg (oral rat), Inhalation: LC50 < 200 ppm / 1 hr. or 2000 mg/m3 / 1 hr. Skin Contact: LD50 < 200 mg/kg (rabbit).

IC: Institutes and Centers. An acronym used at the NIH that refers to organizational and management structure.

Irritant: Non-corrosive chemicals that cause reversible inflammatory effects (swelling and redness) on living tissue by chemical action at the site of contact.

Laboratory: A facility where "lab use of hazardous chemicals" occurs. It is a workplace where relatively small quantities of hazardous chemicals are used on a nonproduction basis.

Laboratory Personnel: Any person working in an NIH laboratory that handles or uses potentially hazardous, and other, chemicals. At the NIH, visiting scientists, guest researchers, special volunteers, students, and other similar personnel are included in the scope of the CHP.

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

Laboratory Use: The handling and use of chemicals in which all of the following conditions are met:

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

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

Organic peroxide: An organic compound that contains the bivalent –o-o- structure and which may be considered to be a structural derivative of hydrogen peroxide where one or both of the hydrogen atoms has been replaced by an organic radical.

Oxidizer: A chemical other than a blasting agent or explosive that initiates or promotes combustion in other materials, thereby causing fire either of itself or through the release of oxygen or other gases. Oxidation reactions are a frequent cause of chemical accidents. When stored, segregate oxidizers from flammable and combustible materials, organic material and reducers.

Particularly Hazardous Substances: These include "select carcinogens," reproductive toxins, and substances that have a high degree of acute toxicity. See Appendix B for guidance in identifying particularly hazardous substances.

Permissible Exposure Limits (PELs): An exposure limit for OSHA regulated substances specified in 29 CFR part 1910.1000, Subpart Z, Toxic and Hazardous Substances.

Peroxide-forming chemicals: A class of compounds that have the ability to form shock-sensitive explosive peroxide crystals. Certain chemicals can turn into dangerous organic peroxides with prolonged storage and/or concentration. Therefore, it is extremely important that procedures be followed regarding the identification, handling, storage, and disposal of peroxide-forming chemicals. Peroxide-forming chemicals react with oxygen – even at low concentrations – to form peroxy compounds. The risk associated with peroxide formation increases if the peroxide crystallizes or becomes concentrated by evaporation or distillation. Factors that affect rate of peroxide formation include exposure to air, light, heat, moisture, and contamination from metals. Avoid the prolonged storage

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of all peroxide-forming chemicals. Especially dangerous are ether bottles that have evaporated to dryness. The following tables list compounds that are known to auto-oxidize to form peroxides and classes of chemicals that can form peroxides upon aging.

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

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

Pyrophoric Chemicals: Pyrophoric materials (e.g., boranes, n-butyllithium, white phosphorus) ignite spontaneously on contact with air. Avoid a flammable spill by storing breakable glass bottles inside a rubber or plastic bottle carrier. Use and store all pyrophorics in an inert atmosphere (e.g., stored under nitrogen or argon).

Reactive Chemicals: Highly reactive chemicals include those which are inherently unstable and susceptible to rapid decomposition as well as chemicals which, under specific conditions, can react alone, or with other substances in a violent uncontrolled manner, liberating heat, toxic gases, or leading to an explosion. Reaction rates almost always increase dramatically as the temperature increases. Therefore, if heat evolved from a reaction is not dissipated, the reaction can accelerate out of control and possibly result in injuries or costly accidents.

Reproductive Toxins: Chemicals that affect an individual's reproductive ability including chromosomal damage (mutations) and/or have an adverse effect on a fetus (teratogenesis).

Select Carcinogen: A substance which meets one of the following criteria:

- It is regulated by OSHA as a carcinogen; or
- It is listed under the category, "known to be carcinogens," in the Annual Report on Carcinogens published by the National Toxicology Program (NTP) (latest edition); or
- It is listed under Group 1 ("carcinogenic to humans") by the International Agency for research on Cancer Monographs (IRAC) (latest editions); or
- It is listed in either Group 2A or 2B by IRAC or under the category, "reasonably anticipated to be carcinogens" by NTP, and causes statistically significant tumor incidence in experimental animals in according with any of the following criteria:

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- After inhalation exposure of 6-7 hours per day, 5 days per week, for significant portion of a lifetime to dosages of less than 10mg/m3.

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

- After oral dosages of less than 50 mg/kg of body weight per day.

Sensitizer: A chemical that causes exposed people or animals to develop an allergic reaction in normal tissue after repeated exposure to the chemical

Shock-Sensitive/Explosive Materials: Can spontaneously release large amounts of energy when struck, vibrated, dropped or agitated. Some chemicals become increasingly shock sensitive with age, so inspect your stock of reactive chemicals regularly to see if they are degraded and should be disposed of. Many laboratory accidents occur from the inadvertent formation of explosive or shock sensitive materials, such as peroxides, perchlorates and azides.

Target organ effects: Effects on specific body systems which may occur as a result of exposure to a hazardous substance. These effects include hepatotoxins, nephrotoxins, neurotoxins, agents which act on the blood or hematopoietic system, agents which damage the lung, reproductive toxins, cutaneous hazards and eye hazards.

Threshold Limit Value (TLV): An airborne concentration of a specific substance under which it is believed that nearly all workers may be exposed for 8 hrs./day, 5 days/week for a working lifetime, without suffering adverse health effects. TLVs are exposure guidelines established by the American Conference of Governmental Industrial Hygienists (ACGIH).

Toxic: A chemical that falls in one of the following categories:

- Has a median lethal dose (LD50) of more than 50 mg/kg but not more than 500 mg/kg of body weight when administered orally to albino rats weighing between 200 and 300 grams each; or

- Has a median lethal dose (LD50) of more than 200 mg/kg but not more than 1,000 mg/kg of body weight when administered by continuous contact for 24 hrs. (or less if death occurs before 24 hrs.) with the bare skin of albino rabbits weighing between 2 and 3 kg each; or

- Has a median lethal concentration (LC50) in air of more than 200 parts per million (PPM) but not more than 2000 PPM by volume of gas or vapor, or more than 2mg/L but not more than 20 mg/L of mist, fume, or dust, when administered by continuous inhalation for 1hr (or less if death occurs within that hour) to albino rats weighing between 200 and 300 grams each.

Unstable (reactive): A chemical which is the pure state, or as produced or transported, will vigorously polymerize, decompose, condense, or will become self-reactive under conditions of shocks, pressure or temperature.

Volatile: Having the tendency or ability to evaporate readily.

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

APPENDIX G
Hazardous Material Spill Procedure

Laboratory emergencies require prompt action to prevent or reduce undesirable effects. Laboratory employees must be able to immediately take control of the situation, and quickly assess the existing and potential hazards and carry out the appropriate response actions.

Immediate hazards of fire, explosion, and release of toxic vapors and gases are of prime concern. The following emergency response procedures contain minimum specifications that must be followed by all NIH laboratory workers. In addition, written emergency response actions for specific hazards in the laboratory (such as skin contact with hydrofluoric acid) must be developed by the department and provided to the laboratory workers. These written emergency response procedures must also specify the proper spill control equipment or material to be used.

Even a small amount of spilled flammable liquid or reactive substance presents a significant fire hazard. There are many spark sources in laboratories. Any uncontained chemical that can disperse fumes, gases or dusts may be hazardous to your health and the health of those around you.

Spill Control Equipment

Where appropriate, each department must make available appropriate spill control items in each laboratory. Items may include commercial spill control products such as inert absorbents and absorbent pads, pillows and rolls, as well as collecting devices such as scoops, brooms, and dustpans. Other chemical-specific neutralizing or absorbing items such as sodium bicarbonate for acid spills, boric acid or citric acid for alkali spills, or activated charcoal for solvent spills should be considered in accordance with frequently used chemicals in the laboratory.

For major spills – a spill that cannot be controlled:

- Everyone leaves the area closing doors behind exiting staff;
- Prevent others from entering the area;
- Initiate first aid at the work site to any exposed or injured employees:
  - **Eyes:** Remove contacts, use eyewash for 15 minutes, holding eyelids open with thumb and index fingers, rolling the eyelids to permit thorough cleaning.

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- **Skin:** Remove contaminated clothing and place in a biohazard bag. Use the closest emergency shower for 15 minutes.

- Call or have a co-worker call the Fire Department: 911 on-campus and 9-911 off-campus;

- Notify the supervisor, if he or she is immediately available;

- Report to OMS, Building 10, Room 6C306 (301-496-4411) within one hour of an exposure (Monday-Friday 7:30 AM to 5:00 PM). If OMS is closed, promptly call the Clinical Center Operator at 301-496-1211 and ask them to page an OMS physician immediately; and

- Do not reenter the room until the Fire Department or appropriate authorities determine that the area is safe.

For minor spills - Non-volatile hazardous chemical liquids that you are familiar with. Resulting from normal use or reaction and can control with material on hand.

- Use appropriate compatible material to clean spill;

- Bag separately; and

- Follow the NIH Waste Disposal Guide for instructions on disposal.

Spill Control for Powders

Powders are positively charged and spread easily. Caution must be used to prevent the contamination of entire lab and adjacent areas.

In the event of a powder spill:

- Step slowly as you leave the lab;

- Leave your shoes and any contaminated clothing (lab coat) at the door;

- Secure the lab preventing access;

- Minimize ventilation;

- On the Bethesda campus call 911; and

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- Avoid tracking through the hallways, you may spread contamination unknowingly.

Spill Control for Acids, Alkalis and Solvents

As a general guideline, spills of less than one liter of these materials are considered small. However, spills of particularly hazardous substances, regardless of the amount spilled, may require immediate Fire Department & DOHS notification and assistance. PHSs include select carcinogens, reproductive toxins and substances with a high degree of acute toxicity.

Whenever a spill occurs, treat the spill as a potentially dangerous situation until the spill is cleaned up or there are positive indications (for example, instrumental monitoring) that no hazard is present. ICs, in conjunction with DOHS, must develop spill response contingency plans to deal with potential releases of extremely hazardous materials that are used in their department.

Mercury Spills

The NIH has developed a mercury policy that will replace mercury-containing equipment with "greener" products where possible.

Liquid mercury is a proven neurotoxin. It has been decided that mercury containing equipment will not be used at the NIH if at all possible. While mercury salts are toxic by ingestion, the prime toxicity of liquid mercury is in the form of vapor. Mercury spills present a special problem because of the difficulty in picking up the tiny droplets and the hazards of undetected residues. Metallic mercury remaining in cracks and crevices will give off toxic vapors for years.

NEVER ADD MERCURY WASTE TO ANY OTHER WASTE OR VICE-VERSA. It all becomes mercury waste, which requires costly disposal.

For all Mercury Spills:

- Leave the area immediately;
- Close the doors;
- Prevent others from entering the area; and
- Call the Fire Department.

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Biohazard Spills

- Quickly assess whether there are any injured persons and attend to any person who may have been contaminated;
- Remove contaminated clothing immediately and decontaminate;
- Close the laboratory door;
- To clean up the spill and decontaminate the area, wear PPE (lab coat, appropriate gloves, and eye protection - safety glasses or goggles). Wear a mask if necessary;
- Cover spill area with an absorbent material;
- Apply a 1:10 solution of household bleach (sodium hypochlorite) directly to the spill area;
- Allow the solution to remain for at least 30 minutes before rinsing; and
- Dispose of all material using a mechanical device such as forceps and place in a BIOHAZARD BAG.

Radioactive Spills

All spills of radioactive substances must be reported to DRS immediately.
Under no circumstances should an untrained person attempt to examine or clean up a spill of radioactive material.

Steps to follow:

- CLEAR THE AREA: Notify all persons not involved in the spill to vacate the room;
- PREVENT THE SPREAD: Cover the spill with absorbent pads, but do not attempt to clean it up. Confine the movement of all personnel potentially contaminated to prevent the spread;
- SHIELD THE SOURCE: If possible, the spill should be shielded, but only if it can be done without further contamination or without significantly increasing your radiation exposure;
- CLOSE THE ROOM: Leave the room and lock the door(s) to prevent entry;
- CALL FOR HELP: Notify DRS immediately;

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- Avoid tracking through the halls;
- Limit movement to prevent area contamination; and
- PERSONAL DECONTAMINATION: Contaminated clothing should be removed and stored for further evaluation by the DRS. If the spill is on the skin, flush thoroughly and then wash with mild soap and lukewarm water.

Leaking Compressed Gas Cylinders

Occasionally, a cylinder or one of its component parts develops a leak. Such leaks often occur around the manifold in areas such as valve threads, safety devices, valve stems and valve outlets.

If a leak is suspected:

- Leave the area immediately;
- Secure the area and deny access;
- On the Bethesda campus call 911;
- Notify Lab manager; and
- Do not return to area until the Fire Department has cleared the area.

Note: Cryogenic liquid containers such as liquid nitrogen, liquid argon, liquid oxygen, and liquid helium may vent periodically to relieve head pressure build up caused by vaporization of product from leakage of heat from the environment into the container. This is a normal process of functioning containers. If a venting event appears abnormal (larger volume or longer duration than normal) follow the procedures listed above.

APPENDIX H
General Decontamination Procedures

Hand Decontamination

- Wash hands completely with soap and water; and
- Rinse completely; dry with a clean towel or air dry.

Clothing, Tool/Equipment Decontamination

- Contact DOHS, the Fire Department and/or the DEP for guidance on cleaning and disposal of contaminated objects;
- It is preferable to use soap and clean water when available; and
- Allow clothes and tools/equipment to air dry thoroughly before re-use.

Important Considerations

- Use gloves and eye protection.

Note: Do not immerse electrical or battery-operated tools/equipment in solutions. Clean exterior with a rag soaked with soap and water or disinfectant solution.

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APPENDIX I
Michael Gottesman Memo
"Laboratory Safety Responsibilities"

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DEPARTMENT OF HEALTH & HUMAN SERVICES

Public Health Service

National Institutes of Health
Bethesda, Maryland 20892

www.nih.gov

Date: May 15, 2015

To: NIH Scientific Directors

From: Deputy Director for Intramural Research

Subject: Laboratory Safety Responsibilities

There is no more important issue to me than the safety of our NIH staff. I regularly discuss important laboratory safety issues, and I am writing to you now about the following concerns and expectations.

A. Laboratory Safety Training: I am reinforcing the importance of laboratory safety training. It is your responsibility to confirm that Lab/Branch Chiefs in your IC or their designees document that all laboratory personnel have taken the role-based mandatory laboratory safety training. A centralized safety training database is available for use by supervisors to document and track the online and classroom training taken by laboratory personnel.

B. IC Laboratory Safety Committees: As you know, your IC Safety and Health Committee (SHC) has authority to oversee and monitor the IC's safety operations. Your responsibilities are to: (1) assure that you have appointed a duly-constituted committee in your IC; (2) walk through all laboratory and intramural research spaces annually (accompanied by your SHC Chair and a representative from the Division of Occupational Health and Safety (DOHS)) to become familiar with the safety and health issues present and to direct appropriate corrective actions; and (3) ensure that the IC SHC surveys all IC space and provides a report to you annually.

C. Use of Personal Protective Equipment (PPE): It is NIH policy and a requirement that appropriate PPE be used by individuals working in a laboratory. At a minimum, this includes wearing long pants, closed-toe shoes and a lab coat while working in the laboratory and/or near hazardous substances. Wearing appropriate gloves for the hazardous substances being handled and the use of protective eyewear are also requirements.

D. Accurate Inventory of Potentially Hazardous Biological Materials: It is your responsibility to assure that each PI maintains an accurate inventory of stored potentially hazardous biological materials (human pathogens worked with at BSL-2 and above, human blood and body fluids and tissues, toxins and animal or plant pathogens) in the centralized database for this purpose.

Finally, as a reminder, only those lab personnel who are certified shippers are allowed to prepare shipments of hazardous materials. Shipper training [https://www.safetytraining.nih.gov/Main.aspx] is provided by DOHS. Additionally, all hazardous materials must be shipped through NIH Freight Forwarding [http://www.ors.od.nih.gov/sr/dohs/BioSafety/shipbio/Pages/shipping_biological_material.aspx].

Your support and enforcement of these requirements and policies are essential to ensure the safe conduct of science at the NIH.

Michael M. Gottesman, M.D.

Michael M. Gottesman, M.D.

cc: Dr. Alfred C. Johnson
Dr. Deborah E. Wilson

APPENDIX J
Laboratory Hazard Analysis

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The Laboratory Hazard Analysis form is on the next page.

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APPENDIX J
Laboratory Hazard Analysis

Name of process:

Chemical name / CAS #:

Identify (if any) environmental conditions (temperature, pressure, anaerobic, etc.):

Describe general procedure:

List physical/health hazards & assoc. engineering controls:

Administrative practices (including storage and waste procedures, OMS requirements):

Personal protective equipment (PPE):

***All laboratory work requires DOHS online and in-class training**: https://www.safetytraining.nih.gov/.*

List additional training required for this laboratory hazard analysis:

Additional comments:

PI Name: _____ Signature: _____ Date:_____

Lab Identifier (e.g. Research Name, Room #):

Researcher(s) Name(s):

1. _____ Signature:_____ Date:_____
2. _____ Signature:_____ Date:_____
3. _____ Signature:_____ Date:_____
4. _____ Signature:_____ Date:_____
5. _____ Signature:_____ Date:_____
6. _____ Signature:_____ Date:_____
7. _____ Signature:_____ Date:_____
8. _____ Signature:_____ Date:_____
9. _____ Signature:_____ Date:_____
10. _____ Signature:_____ Date:_____

APPENDIX K
Laboratory Personnel Safety Check List

Page intentionally left blank.
The Laboratory Personnel Safety Check List is on the next page.

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APPENDIX K
Laboratory Personnel Safety Check List

Employee/Student Name: _____ Date: _____
IC/Branch/Unit: _____ Bldg: _____ Rm. #: _____
Principal Investigator: _____ and/or Lab Supervisor: _____

The following procedures have been reviewed with this person prior to working in the laboratory.

1. Has the PI/Lab Supervisor discussed the nature of the research being conducted in the laboratory? ☐

2. Has the PI/Lab Supervisor discussed all hazardous components of the research? ☐
   a. Chemical ☐
   b. Biological ☐
   c. Physical ☐

3. Has the employee/student received instruction on known symptoms associated with exposure to highly toxic chemicals or infectious agents used in the laboratory? ☐

4. Has the PI/Lab Supervisor discussed the need for the employee/student to inform health care providers of the hazardous substances used in the laboratory during each medical visit? ☐

5. Has the PI/Lab Supervisor reviewed the laboratory Chemical Hygiene Plan, Laboratory Hazardous Analysis and/or safety operating procedures with the employee/student? ☐

6. Has the PI/Lab Supervisor identified the location of Safety Data Sheets to the employee/student and demonstrated methods of access? ☐

7. Has hazard assessment information concerning Personal Protective Equipment required in laboratory been reviewed, and has the supervisor and employee signed off? ☐

8. Does the employee/student need a respirator? If yes, arrange for exposure evaluation, training and fit testing through the Division of Occupational Health and Safety. ☐

9. Have all Emergency Equipment locations/procedures been identified to the employee/student?

   a. Emergency Shower ☐
   b. Emergency Eyewash ☐
   c. Fire Alarm Pull Station ☐
   d. Fire Extinguisher ☐
   e. Spill Kit ☐
   f. Telephone (9-1-1) ☐

10. Has the PI/Lab Supervisor reviewed with the employee/student, the laboratory signage system as indicated on the door? ☐

11. Have basic laboratory safety requirements been explained & reinforced? ☐

14. Has the employee/student signed up for the appropriate Laboratory Personnel Training? See https://www.safetytraining.nih.gov/. ☐

All laboratory personnel must:

- ☐ **know** the hazards
- ☐ **understand** the hazards
- ☐ **have skills** to execute safe practices

Employee/Student _____ _____

Signature Date

Principal Investigator/ _____ _____

Lab Supervisor Signature Date

APPENDIX L
Program Evaluation and Improvement

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The Program Evaluation and Improvement template is on the next page.

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Program Evaluation and Improvement

CHP CY [Insert Calendar Year of Review]

This table will be completed in accordance with the guidance provided by OSHA's webpage on Recommended Practices for Safety and Health Programs

Requirement	Not Implemented	Partially Implemented	Implemented with only Minor Deficiencies	Fully Implemented	Evidence of Implementation	Planned Improvements
Performance indicators are used to track progress toward program goals.				✓		
Performance is tracked using both lagging and leading indicators.				✓		
Performance data are analyzed and shared with workers.				✓		
Management does an initial review (and subsequent annual reviews) to evaluate the program and ensure that it is fully implemented and functioning as planned.				✓		
Workers are involved in all program review activities.				✓		
Program reviews examine key processes to ensure that they are operating as intended.				✓		
The program is modified as needed to correct shortcomings.				✓		

This is a template only – as such it is filled out each year and used internally to guide future improvements.