

2015

NATIONAL INSTITUTES OF HEALTH | OFFICE OF RESEARCH SERVICES | DIVISION OF OCCUPATIONAL HEALTH AND SAFETY

Chemical Safety Guide

A companion to the NIH Chemical Hygiene Plan and Hazard Communication Program



National Institutes of Health
Office of Management



Globally Harmonized System

The United Nations adopted the Globally Harmonized System (GHS) to provide an internationally standardized approach to the classification and labeling of chemicals. The Occupational Safety and Health Administration (OSHA) is modifying its Hazard Communication Standard (HCS) to conform with the GHS and ensure consistency of information. Compliance with some changes begins December 2013, with full compliance required within two years. The changes include:

Hazard classification: Provides specific criteria for classification of health, physical and environmental hazards, as well as classification of mixtures.

Labels: Chemical manufacturers and importers are required to provide a label that includes a harmonized signal word, pictogram and hazard statement for each hazard class and category, along with precautionary statements.

Safety Data Sheets (SDS): Previously called, Material Safety Data Sheets, will have a specified 16-section format.

Signal word: There are two signal words in the GHS system - Danger and Warning. These signal words are used to communicate the relative level of hazard on both the label and the SDS, with "Danger" indicating the more severe hazard. The appropriate signal word is determined by the hazard classification.

Information and training: While the GHS does not address training, the proposed HCS requires that all personnel working with chemicals be properly trained to recognize and understand the new labels and safety data sheets.

Classification of physical, health and environmental hazards:

PHYSICAL HAZARDS			HEALTH HAZARDS		
Label Elements		Hazard Classes	Label Elements		Hazard Classes
Old	New		Old	New	
 Explosive	 Danger	• Unstable explosives • Self-reactive substances and mixtures • Organic peroxides	 Very toxic/toxic	 Danger	• Acute toxicity • Fatal if inhaled, in contact with skin, or swallowed
No classification	 Warning	Explosives	 Toxic	 Danger	• Acute toxicity • Toxic if inhaled, in contact with skin, or swallowed
 Extremely flammable	 Danger	Extremely flammable liquids, vapors, gases and aerosols	 Harmful	 Danger	• Specific target organ toxicity (single or repeated exposure) • Carcinogenicity • Germ cell mutagenicity • Reproductive toxicity
 Highly flammable	 Warning	Highly flammable liquids and vapors	 Harmful	 Warning	• Respiratory sensitization • Aspiration hazard • Specific target organ toxicity (single or repeated exposure) • Carcinogenicity • Germ cell mutagenicity • Reproductive toxicity
No symbol	 Warning	Flammable liquids, vapors, and aerosols	 Harmful	 Warning	• Acute toxicity • Harmful if inhaled, in contact with skin, or swallowed
No classification	 Warning		 Harmful	 Warning	
 Highly Flammable	 Warning	• Pyrophoric liquids and solids • Substances and mixtures, which in contact with water, emit flammable gases	 Corrosive	 Danger	Skin corrosion
 Oxidizing	 Danger	• Self-heating substances and mixtures • Self-reactive substances and mixtures • Organic peroxides	 Irritant	 Danger	Causes serious eye damage
 Oxidizing	 Danger/Warning	Oxidizing liquids	 Warning	 Warning	• Causes serious eye irritation • Specific target organ toxicity, single exposure (may cause respiratory irritation) • Skin irritation • Skin sensitization
No classification	 Danger/Warning		No symbol	 Warning	• Specific target organ toxicity, single exposure (may cause drowsiness and dizziness)
No classification	 Warning	Gases under pressure: – compressed – liquefied – refrigerated liquefied – dissolved	ENVIRONMENTAL HAZARDS		
Label Elements		Hazard Classes	Label Elements		Hazard Classes
Old	New		Old	New	
	 Warning	Corrosive to metals		 Warning	• Hazardous to the aquatic environment - acute • Hazardous to the aquatic environment - chronic

Labeling

In compliance with GHS, chemical manufacturers and importers are required to provide a label that includes six elements:

1. Product identifier
2. Signal word
3. Pictogram
4. Hazard statement
5. Precautionary statement
6. Product supplier

EPICHLOROHYDRIN ①
UN No. 2023
CAS No. 106-89-8

② **DANGER**

③

④
Flammable liquid and vapor. Toxic if swallowed. Toxic in contact with skin. Causes severe skin burns and eye damage. May cause an allergic skin reaction. May cause cancer.

⑤
Do not breathe dust/fume/gas/mist/vapor/spray. Wear protective gloves/protective clothing/eye protection.

⑥
Fill Weight: 18.52 lbs. Lot number: AO323111323
Gross weight: 20 lbs Fill Date: 1/15/2012

Jackson Chemical Company - City of Industry, Los Angeles, California, USA (800)-444-456-8989

Once in the lab, the user may not obscure or remove any of the label elements from the container. If the chemical is transferred into a different container, the name of the chemical and any associated hazards must also be placed on that container; The label must be legible, in English, and prominently displayed on the container.

This includes:

- All chemicals transferred from original container
- Any prepared solution
- Secondary containers within which a chemical is stored
- Chemical waste (the word “waste” must also appear on the label)

NOTE Containers of newly synthesized chemicals have unknown hazards. Label these containers with hazard information as best determined. It is important to include the location (lab notebook, computer file) for finding specific information, such as:

- Chemical name, exactly as it appears on the outside of the container
- Molecular formula
- Molecular weight (if known)

Safety Data Sheets

Safety Data Sheets (SDS) will replace Material Safety Data Sheets (MSDS) under the Globally Harmonized System. They will present details of the chemical hazards in a standardized format to improve clarity and comprehension.

The SDS is to include the following sixteen sections in this order:

1. Identification
2. Hazards identification
3. Composition/information on ingredients
4. First aid measures
5. Firefighting measures
6. Accidental release measures
7. Handling and storage
8. Exposure controls/personal protection
9. Physical and chemical properties
10. Stability and reactivity
11. Toxicological information
12. Ecological information
13. Disposal considerations
14. Transport information
15. Regulatory information
16. Other information



Image courtesy of Mastery.com



1

Hazard Identification



Hazard Assessment

A Chemical Hazard Assessment identifies the hazards of the chemicals and processes used in the laboratory. The Assessment evaluates the potential for risk and the severity of the risk associated with the hazards. The Assessment determines measures to eliminate, minimize, or control the hazards and potential risks.

What needs to be done?

To perform a Chemical Hazard Assessment, laboratory workers should examine their plan for an experiment and identify any chemicals with which they are not familiar. The SDS for

each unfamiliar chemical should be reviewed. SDSs should be maintained by the laboratory in a central location, accessible either as a hard copy or electronically.

Who does the Assessment?

The Principal Investigator or Supervisor with primary responsibility for specific hazard training, performs the Chemical Hazard Assessment. He or she may consult with colleagues or Safety Specialists from the Division of Occupational Health and Safety (DOHS).



Identify steps in a procedure where hazard controls are needed.

What does it entail?

A Chemical hazard Assessment entails gathering information about the properties and proposed use of a chemical or reagent. This information should include:

1. SDS for the chemical or reagent
2. Description of work/activities/use
3. Storage requirements
4. Disposal and environmental requirements
5. Health surveillance
6. First aid/emergency procedures
7. Proposed controls, to include:
 - Chemical substitution
 - Isolation
 - Engineering controls
 - Administrative controls
 - Practices and procedures
 - Personal protective equipment

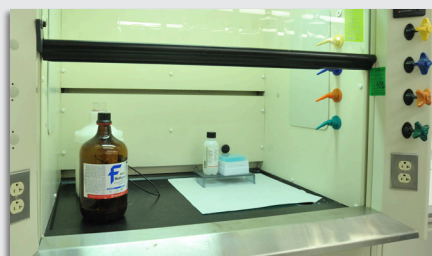
Chemical Hazard Assessment

Name of Process: _____		
Chemical Name/CAS #: _____		
Signs/Symptoms of Exposure: _____		
Date Prepared: _____		Date Last Reviewed: _____
IC: _____	Building: _____	Room(s): _____
PI Name: _____		Lab: _____
Procedure Step	Hazards Associated with Step (e.g., Physical, Health, Environment)	Controls
		Engineering: _____
		Administrative: _____
		PPE: _____
		Other: _____

Control of Exposure

The best way to control or minimize exposures is to eliminate the hazard.

If a hazard cannot be eliminated, other hazard control methods must be used. Personal protective equipment (PPE) should never be the only method used to reduce exposure because PPE may “fail” (stop protecting the worker) with little or no warning.



Engineering control



Administrative control



Personal Protective Equipment

Engineering Controls:

- Use a certified chemical fume hood or other local exhaust ventilation whenever opening, pouring, or handling hazardous chemicals.
- Store chemicals in the proper locations. Do not use or store chemicals or compressed gases in cold or warm rooms because the air inside is recirculated.
- Ensure that air flows into the lab to contain hazardous particles and noxious odors. (see “Ventilation” section)

NOTE Prevention is the most effective means of hazard control. Prepare your work area before beginning any work!

Administrative controls:

- Ensure personnel are adequately trained on the chemicals and associated processes.
- Never pipette by mouth.
- Transport laboratory chemicals using bottle carriers, secondary containment, and/or suitable carts.
- Follow the established procedures for the decontamination and movement of scientific and medical equipment found in the NIH Personal Property Management Guide.
- In the event of a hazardous chemical spill, immediately follow the hazardous material spill procedure (see next page).
- Store all food, beverages, cosmetics, and medications outside the lab.
- Keep all doors to the laboratory closed to ensure proper fume hood performance and directional airflow into the lab.
- Ensure unimpeded access to safety showers, eyewash stations and exit pathways.

- Test flush eyewash stations weekly and document the date and initials of the individual who performed the test. Call ORF (301-435-8000) to have failed tests corrected immediately.
- Call Office of Research Facilities (ORF) (301-435-8000) to have the safety showers tested annually.
- Contact Division of Occupational Health and Safety (DOHS) (301-496-2346) for clearance of the workspace when non-laboratory personnel have to enter the laboratory to perform services such as renovations or equipment repair. (Routine services such as floor cleaning and trash collection do not require clearance.)
- Keep personal protective equipment, emergency phone numbers, and fire extinguishers readily available.

Personal Protective Equipment:

- Protect your clothes and exposed skin by wearing appropriate personal protective equipment. Consult the PPE section for detailed information.
- Do not wear PPE outside the laboratory.
- Remove gloves carefully and thoroughly wash hands and forearms upon completion of work and before leaving the laboratory.
- Wear eye protection when a splash potential exists.

NOTE Contact lenses may be worn, with some exceptions, but do not function as protective devices. The NIOSH Current Intelligence Bulletin prohibits wear of contact lenses when working with acrylonitrile, methylenechloride, 1,2 dibromo-3-chloropropane, ethylene oxide, and methylene dianiline.

Prevention:

Most spills are preventable. The following are some tips that could help to prevent or minimize the magnitude of a spill:

- Substitute a less hazardous chemical whenever possible.
- Think through each step of your experiment carefully.
- Order/use the smallest quantity of chemicals possible.
- Use bottle carriers to transport all glass bottles containing chemicals.
- Order solvents and acids in poly-coated glass safety bottles. The protective coating on these bottles can provide containment if the bottle breaks.
- Use secondary containment when possible.
- Do not store bottles near the edges of shelves and bench tops.

Major spills:

⚠️ ALERT Call the Fire Department: 911 on-campus and 9-911 off-campus. If calling from a cell phone, call 301-496-9911.

A major spill is defined as one that requires an emergency response. If ANY of the following criteria are met, an emergency response must be initiated:

1. Assistance from outside the immediate release area is required.
2. The incident is likely to result in an uncontrolled release of hazardous substances (to drains, to the air, etc.)
3. Response to a release poses a potential safety or health hazard to the responder.
4. The employee is uncomfortable.

If you witness or are involved in a spill situation:

1. Leave the area, closing doors behind you.
2. Prevent others from entering the area.
3. Initiate first aid at the work site:
 - Eyes: Flush with eyewash for 15 minutes, holding eyelids open with thumb and index finger.
 - Skin: Remove contaminated clothing. Use closest emergency shower for 15 minutes.
4. Notify your supervisor, if he/she is immediately available
5. Report (Monday-Friday 7:30 AM to 5:00 PM) to the Occupational Medical Service (OMS), Building 10, Room 6C306 (301-496-4411) as soon as possible. If OMS is closed, report the incident the following day or as soon as possible.
6. Do not reenter the room until the Fire Department or appropriate authorities determine that the area is safe.

Minor spills:

As a general guideline, low-volume spills that are within a lab or contained area (such as a bench top or inside the chemical fume hood) AND are low hazard (NOT chemicals which are toxic, corrosive, flammable or reactive) are considered minor. HOWEVER, DO NOT attempt to clean up a spill unless you have the training and resources to clean the spill with no risk to yourself or others. Attempt ONLY if it is a non-volatile liquid with which you are familiar, and you have appropriate supplies on hand, including:

- Personal protective equipment: safety goggles, chemically resistant gloves, lab coats.
- Absorbent, compatible material to contain the spill.

- Disposal container (or bag) to collect absorbent material. Dispose as chemical waste.

NOTE Some chemical spills must be cleaned up by the Fire Department. The following substances are very hazardous and clean up must be performed by experienced personnel only:

Aromatic amines, nitro compounds, organic halides, bromine carbon, disulfide ethers, cyanides, hydrazines, and nitriles

NOTE Breakthrough time for some nitrile gloves may be quite short; use thick nitrile gloves or multi-hazard gloves such as Silver Shield®. Always check the manufacturer's guide for compatibility.

Place absorbents and other contaminated materials in the same disposal container.

Label disposal containers with the contaminant, room number, name of person responsible for cleanup, and date. Attach Chemical Waste Tag (CWT) and call Chemical Waste Services for pick-up.

NOTE ALWAYS report to OMS in the event of a chemical exposure, no matter how minor.



Call 9-1-1 in the event of a large spill.



Use eyewash for 15 minutes.

Chemical Storage

Proper chemical storage can be a challenge in the limited space of laboratories. The hazards associated with chemical storage can be reduced through prudent purchasing, handling and disposal practices.

Considerations for proper storage:

Ensure all hazardous chemicals are properly labeled.

Record the date of receipt on each bottle to assist with inventory management.

Record the date of opening on each peroxide former and dispose prior to the expiration date (See the Chemical Hygiene Plan).

Label and date solutions when prepared with the name of the chemical or mixture and any applicable hazard warnings. See additional information in Hazard Identification/Labeling section.

Segregate and store incompatibles separately by hazard class. Within a hazard class, chemicals may be stored alphabetically.

Store flammable and combustible materials in an approved storage cabinet if the volume exceeds one gallon. Keep cabinet doors closed.

Always store hazardous chemicals no higher than eye level and never on top of a storage unit. Do not overcrowd shelves.

Do not store chemicals on the floor.

Liquids should be stored on shelves with a lipped edge and in spill trays to hold the contents if the container breaks or leaks.

Store acids in a dedicated acid cabinet, preferably in the ventilated storage area beneath the chemical fume hood. Nitric, perchloric, chromic and sulfuric acids are strong oxidizers and must be kept isolated from organic acids.

Store bases in a corrosives cabinet.

Store highly toxic materials in a closed, dedicated poison cabinet.

Do not use the work surface of chemical fume hoods to store containers and equipment, as this prevents proper air flow, reduces available work space, and may increase hazards in case of fire or spill.

✓ TIP Use work surface of a shelf to hold supplies inside a fume hood to avoid blocking the rear baffle and disrupting proper operation of the hood.

Chemicals to be stored in a refrigerator or freezer must be in units appropriately rated hazardous material storage.

NEVER store hazardous chemicals in a cold room or other storage area with recirculating ventilation.



Store acids beneath the chemical fume hood.



Store bases in a corrosives cabinet.



Store chemicals on spill trays to contain leaks or drips.



3 Storage, Handling and Transport

Do not store hazardous chemicals under a sink.

Secure all compressed gas cylinders. Keep protective caps on cylinders (including during transport) when not in use. Remove empty cylinders as soon as possible.

Store chemicals away from heat and direct sunlight.

Rotate chemical inventory. Dispose of chemicals on their expiration date.

Inspect chemical containers regularly for deterioration and integrity.

Store chemicals under appropriate conditions. Chemicals are stable only when stored in an inert gas such as nitrogen. They may burst into flame when exposed to air or moisture in the air. See the SDS for guidance.

Consult safety references (e.g., SDSs) before working with chemicals that are new or unfamiliar.

Considerations For Ordering:

- Purchase less hazardous alternatives whenever possible.

- Keep a chemical inventory to avoid duplicate purchases.
- Purchase chemicals in reasonable quantities that will be used within six months of purchase.

NOTE If an old or expired container of a peroxide-forming chemical or reactive is found, do not move it. Contact the Division of Environmental Protection (DEP) at 301-496-4710 for assistance in disposing of the container.

Chemical Transport

Moving chemicals within your laboratory:

- Inspect each container's cap or closure seal for the formation of crystals.

ALERT Do not tighten, open or move containers that have crystals forming on the caps and seals; contact DEP immediately for removal.

- Use carts or bottle carriers to move chemicals short distances.
- Place chemicals in sturdy secondary containers.

Moving chemicals outside of your lab:

Chemical transportation services are available through the DEP. Please contact DEP (301-496-7990) and your DOHS Safety Specialist for guidance when you are planning a laboratory move or before you move any chemicals.



Move chemicals safely on a cart.



Inspect bottle caps for crystals.

Chemical Segregation

Class of Chemical	Examples	Recommended Storage Method	Incompatible Materials	Possible Reaction If Mixed
Corrosive Acids	Organic and Mineral Acids – Acetic Acid – Glacial Acetic Acid – Butyric Acid Oxidizing Acids – Nitric Acid – Sulfuric Acid – Perchloric Acid – Phosphoric Acid	Separate ventilated cabinet or storage area away from potential water sources (NOT under the sink) *Store concentrated Nitric Acid (≥68%) and Sulfuric Acid (≥93%) in a secondary container away from other chemicals/acids.	Flammable Liquids Flammable Solids Acids Oxidizers Poisons	Heat Gas Generation Violent Reaction
Corrosive Bases/ Caustics	Ammonium Hydroxide Sodium Hydroxide Calcium Hydroxide	Separate cabinet or storage area away from potential water sources (NOT under the sink)	Flammable Liquids Flammable Solids Acids Oxidizers Poisons	Heat Gas Generation Violent Reaction

Class of Chemical	Examples	Recommended Storage Method	Incompatible Materials	Possible Reaction If Mixed
Explosives	Ammonium Nitrate Nitro Urea Picric Acid* Trinitroaniline Trinitrobenzene Trinitrobenzoic Acid Trinitrotoluene Urea Nitrate	Secure location away from other chemicals *Consult DFM or DOHS for additional information.	Flammable Liquids Oxidizers Poisons Acids Bases	Explosion Hazard
Flammable Liquids	Acetone Benzene Diethyl Ether Methanol Ethanol Toluene Glacial Acetic Acid	Flammable storage cabinet Refrigerator rated for flammable/hazardous storage	Acids Bases Oxidizers Poisons	Fire Hazard Heat Violent Reaction
Flammable Solids	Phosphorus Magnesium Ethyl Acetate	Dry cool area, away from other chemicals, and away from each other	Acids Bases Oxidizers Poisons	Fire Hazard Violent Reaction
Oxidizers	Sodium Hypochlorite Ethyl Acetate Benzoyl Peroxide Potassium Permanganate Potassium Chlorate Potassium Dichromate Peroxides Perchlorates Chlorates Nitrates	Store separately from flammable and combustible materials	Reducing Agents Flammables Combustibles Corrosives	Fire Hazard Toxic Gas Generation
Poisons	Cyanides Cadmium Mercury Osmium Acrylamide Ethidium Bromide Sodium Azide	Vented, cool, dry area in un-breakable chemically resistant secondary containers Heavy Metals	Flammable Liquids Acids Bases Oxidizers Corrosives	Generation of Toxic & Flammable Gas Violent Reaction
Water Reactive	Sodium Metal Potassium Metal Lithium Metal Lithium Aluminum Hydride	Dry, cool location away from potential spray from fire sprinklers and other water sources (NOT under the sink)	Aqueous Solutions Oxidizers	Heat Violent Reaction
Flammable Compressed Gases	Methane Acetylene Propane Hydrogen	Cool, dry area away from oxidizing gases while securely attached to wall or bench	Oxidizing & Toxic Compressed Gases Oxidizing Solids	Fire Hazard Explosion Hazard
Oxidizing Compressed Gases	Oxygen Chlorine	Cool, dry area away from flammable gases while securely attached to wall or bench	Flammable Gases	Fire Hazard Explosion Hazard
Poisonous Compressed Gases	Carbon Monoxide Hydrogen Sulfide Hydrogen Chloride	Cool, dry area away from flammable gases or liquids while securely attached to wall or bench	Flammable Gases Oxidizing Gases	Release of Toxic Gas Violent Reaction

Adapted from: University of Texas/Health Science at Houston



Chemical Waste Disposal

Waste disposal procedures are described in detail in the **NIH Waste Disposal Guide** (<http://orf.od.nih.gov/EnvironmentalProtection/WasteDisposal/Pages/default.aspx>). Below are general guidelines:

DON'T:

Don't mix incompatible chemicals.

Don't discard chemicals in sinks, medical pathological waste (MPW) boxes, or general trash.

Don't treat chemical waste in any manner, including use of ethidium bromide filters.

Don't dispose of volatile chemicals by evaporation.

Don't put waste containers in hallways or other public locations.

Don't move chemicals with precipitation on or in the bottle.

NOTE Picric acid is a commonly used reagent in biological laboratories which becomes a dangerous explosive if allowed to crystallize. If dehydrated picric acid is discovered, DO NOT MOVE THE BOTTLE, call DEP for removal!

DO:

Keep waste containers closed at all times.

Store waste in laboratory while awaiting pick up.

Place liquid waste containers in secondary containers (pans).

Have chemical waste picked up within 60 days of accumulation start date.

Dispose of empty chemical bottles as chemical waste or recycle.

Use only the safety cans provided by the Chemical Disposal Service for disposing of flammables.

Attach and complete a chemical waste tag to ALL chemical waste not in its original container.

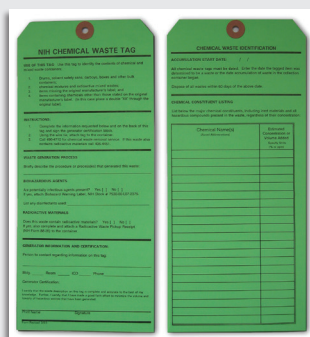
Contact DEP or your DOHS Safety Specialist if you are unsure how to dispose of a chemical.

Consider an annual Chemical Clean-up Day to dispose of old or unwanted chemicals.

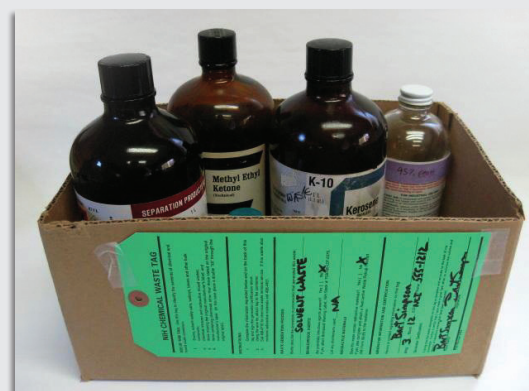
- One box should be for dry chemicals, one for acids, one for bases and one for flammables.
- Flammable liquids can be placed into either the acids box or bases box, but not both.
- Leave original labels on bottles whenever possible
- Try to categorize unknown chemicals (any information). This may help avoid the expense of identifying unknown chemicals.
- Affix a Chemical Waste tag to each box, identifying contents.
- Call DEP for pick-up at 301-496-4710

***Certain items may require special handling based on the stability of the material.** These items may include peroxide formers, explosives, water reactive chemicals, as well as shock, air and temperature sensitive items. CALL DEP FOR REMOVAL OF THESE ITEMS.

In 2009, the NICHD Safety Committee carried out an NICHD-wide cleanup of old and unused chemicals. They collected ~60 boxes. This not only reduced the hazards in their labs, but freed up additional storage space.



Chemical Waste Tag and examples of correct disposal techniques



Highly Reactive Chemicals

Highly reactive chemicals include those which are inherently unstable and susceptible to rapid decomposition. Also, those chemicals which can react alone or with other substances in a violent uncontrolled manner, liberating heat, toxic gases, or leading to an explosion.

Air, light, heat, mechanical shock (when struck, vibrated or otherwise agitated), water, and certain catalysts can cause decomposition of some highly reactive chemicals, and initiate an explosive reaction. Hydrogen and chlorine may react explosively in the presence of light. Alkali metals, such as sodium, potassium and lithium, react violently with water liberating hydrogen gas. **Examples of shock sensitive materials include acetylides, azides, organic nitrates, nitro compounds, and peroxides.** When working with highly reactive chemicals, employees should conduct a Chemical Hazard Assessment.

Organic Peroxides are extremely sensitive to light, heat, shock, sparks, and other forms of accidental ignition, as well as to strong oxidizing and reducing materials. All organic peroxides are highly flammable. Peroxides may deteriorate quickly. Always dispose of peroxides upon expiration.

Peroxide Formers can form peroxides spontaneously during storage and especially after exposure to the air. This is particularly dangerous if:

- peroxides are present during a distillation, where applied heat to the concentrated solution may trigger a violent explosion.
- peroxides evaporate, leaving the crystals of highly explosive peroxide at the bottom of the container.

Peroxide forming chemicals must be labeled with the date of receipt from the manufacturer and the “opened” date.

NOTE Avoid the distillation, concentration, or evaporation of peroxide formers by first testing for the existence of peroxides. Peroxide detection test strips are available from most lab equipment supply companies.

Chemicals that are sensitive to peroxide formation can be broken into three categories shown in the following table:



Label peroxide forming chemicals with “received” and “opened” dates

Peroxide hazard after prolonged storage. Form potentially explosive peroxides without concentrating. All have been responsible for fatalities.	Chemicals which become a peroxide hazard if concentrated, such as through distillation or evaporation.	Chemicals which are hazardous due to peroxide initiation of polymerization.
Discard after 3 months.	Discard after 1 year (or 6 months after opening).	Discard after 1 year.
divinyl acetylene isopropyl ether potassium amide potassium metal sodium amide sodium ethoxyacetylide vinylidene chloride	acetal acetaldehyde cumene cyclohexane cyclopentene diacetylene dicyclopentadiene diethyl ether dioxane ethylene glycol dimethyl ether furan methyl acetylene methyl cyclopentane methyl-isobutyl ketone tetrahydrofuran tetrahydronaphthalene vinyl ethers	acrylonitrile butadiene chlorobutadiene chlorotrifluoroethylene styrene tetrafluoroethylene vinyl acetate vinyl acetylene vinyl chloride vinyl pyridine

Safe Management of Particularly Hazardous Substances in NIH Laboratories

What are Particularly Hazardous Substances (PHS)?

PHS are chemicals that may pose extreme hazards to laboratory employees. As defined by the OSHA Laboratory Standard (29 CFR 1910.1450), PHS include *certain carcinogens* (those strongly implicated as a potential cause of cancer in humans), *reproductive toxins*, and *substances with a high degree of acute toxicity*.

OSHA and NIH require the development of protocols for the identification and management of PHS.



Who is responsible for identifying and managing PHS in NIH labs?

The Principal Investigator (PI) has primary responsibility for determining which chemicals must be handled as PHS. Each PI is also responsible for ensuring that employees follow appropriate protective measures and receive training when working with any PHS. DOHS (301-496-2960) can provide assistance upon request.

My laboratory uses numerous hazardous chemicals. How do I determine which ones must be classified as PHS?

First, review each chemical's properties. Chemicals that may be considered PHSS include:

- substances that may cause severe, acute, or lethal effects through any exposure route (inhalation, injection, skin absorption, or ingestion) in quantities of 50 micrograms per kilogram of body weight (50 µg/kg) or less;
- highly unstable or explosive materials, alone or in combination with other materials;
- carcinogens;
- reproductive toxins;
- materials that may generate acutely toxic by-products that could overwhelm control measures or penetrate personal protective equipment;
- substances that have been determined by DOHS to present a unique hazard or are used in an operation that requires approval above the level of the laboratory supervisor.

*Then, if a substance meets **any of the above criteria**, the PI must consider whether its use poses a significant hazard.* For instance,

- Is the chemical handled rarely, occasionally, or repeatedly?
- Is the procedure done on the open bench, in a laboratory hood, or in an enclosed apparatus?
- Is there a potential for the employee to be exposed to the chemical?
- Does the chemical's use pose a significant potential for exposure through any route (inhalation, skin, or ingestion)? For instance, is it highly volatile? Are dusts or aerosols formed? Is it heated or concentrated?
- What is the reproductive status of employees (e.g., pregnant or planning to conceive)? Reproductive toxins may affect the reproductive health of both men and women.
- Do any employees have known chemical sensitivities?
- Is there a potential for new or unknown substances to be created during the procedure?
- Are the signs and symptoms of exposure readily apparent?



Once I have identified all the PHS in my lab, what do I next?

1. Determine whether or not the chemical can be replaced with a less hazardous chemical.
2. Write a PHS-specific safety protocol that addresses:
 - Each PHS's potential physical and health effects;
 - A Step-by-step review of the work involving the PHS;
 - The engineering controls, work practices, and PPE for the PHS;
 - Establishment of a clearly-marked designated area for use of the PHS;
 - Procedures for labeling, storage, and safe removal of contaminated waste;
 - Decontamination procedures; and
 - Employee training



3. Approve the use of the PHS only after employees have been trained according to the safety protocol. Document that all employees who work with any PHS have received proper training and a copy of the written safety protocol.

NOTE Medical counseling through the Occupational Medical Service (OMS) is offered for employees working with hazardous chemicals. OMS provides additional services to employees working with potentially hazardous chemicals that monitor individuals for adverse health effects, and determines treatment strategies that can help to prevent or significantly reduce adverse health effects if exposed. These include medical surveillance and post-exposure treatment and follow-up programs.

Where can I get more information?

For assistance with PHS or any other lab safety questions, contact the DOHS at 301-496-2960. See also:



NIH Chemical Hygiene Plan (CHP), Appendix A, Guidance for Identifying Particularly Hazardous Substances, www.ors.od.nih.gov/sr/dohs/Documents/NIH-CHP.pdf

National Research Council, *Prudent Practices in the Laboratory: Handling and Management of Chemical Hazards*, National Academy Press.



OSHA standard 29 CFR 1910.1450. Occupational exposure to hazardous chemicals in laboratories, http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=standards&p_id=10106

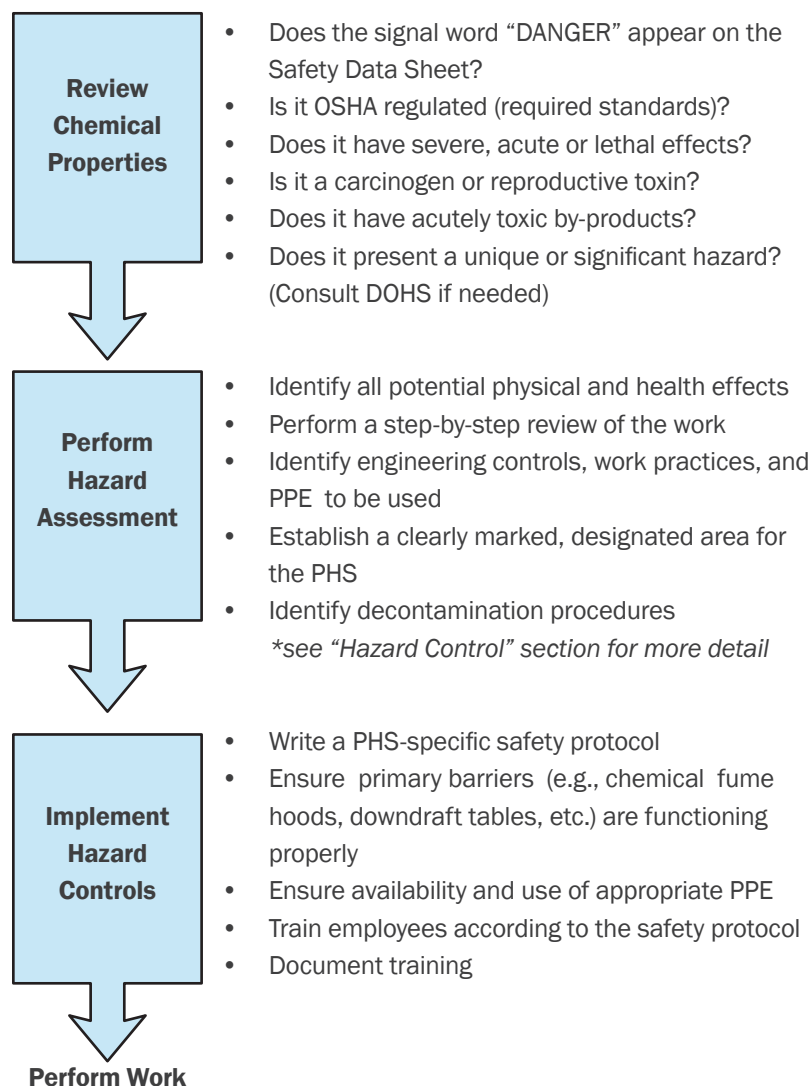


Appendix B of the OSHA laboratory standard (1910.1450) contains a list of references, at http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10108



OSHA Laboratory Safety Guidance booklet, OSHA 3404-11R, 2011, available at <http://www.osha.gov/Publications/laboratory/OSHA3404laboratory-safety-guidance.pdf>

Safe Management of Particularly Hazardous Substances in NIH Laboratories





Toxic Chemical Reduction Initiative

NIH developed the Toxic Chemical Reduction Initiative in conjunction with the requirement for strict control of Particularly Hazardous Substances, and in response to the mandate of Executive Order 13514 and NIH's environmental goal to reduce toxic and hazardous chemical use, NIH developed the Toxic Chemical Reduction Initiative. This initiative identified alternatives that are less toxic and more

environmentally friendly than their more hazardous counterpart. This venture was spearheaded by the Division of Environmental Protection through the NIH Environmental Management System (NEMS). About 200 toxic chemicals were scored numerically and ranked based on the following four criteria for reduction:

- Health and safety risk
- Quantity generated
- Mandated regulatory reduction
- Alternative availability and feasibility

(For more information about this initiative, visit the NIH Environmental Management System (NEMS) website at www.nems.nih.gov)

Compressed Gases

Hazards associated with compressed gases include:

- Oxygen displacement
- Fires
- Explosions
- Toxic gas exposures
- Physical hazards associated with high pressure systems.

Special storage and handling precautions are necessary in order to control these hazards.

Storage

All cylinders must be secured to a wall, bench or fixed support using a chain or strap placed at 2/3 the height of the cylinder. Cylinder stands are an alternative to straps.

Do not store full and empty cylinders together.

Keep the number of cylinders in the laboratory to a minimum and ensure that the cylinder contents are properly and prominently labeled.

Keep empty compressed gas cylinders closed and secured, and stored so that they may be removed with a minimum handling of other cylinders.

Empty cylinders should be stored so that they may be removed easily.

Handling

Be familiar with the hazards of the compressed gas (consult the SDS).

Use a suitable hand truck or cart equipped with a chain or belt for securing the cylinder to the cart, even for short distances.

Cylinder caps should be secured on each cylinder unless in use. Cylinder caps protect the valve on top of the cylinder from damage.

Never tamper with pressure relief devices in valves or cylinders.

Use a crescent wrench, not a pipe wrench (it roughens the edges of the nut), when manipulating the regulator.

Keep the cylinder valve closed except when in use.

Use compressed gases only in a well-ventilated area; never use or store them in a cold room.

Toxic, flammable and corrosive gases should be handled in a chemical fume hood.

Where more than one type of gas is in use, label gas lines.

Inspect valves and tubing regularly for wear and tear, and for leaks using soapy water.

Use the appropriate regulator for the cylinder; never substitute another regulator.

Don't use oil or grease to seal the O-ring on the regulator.



Cryogenic Liquids and Solids

Nitrogen and helium

Nitrogen and helium are the most commonly used cryogenic liquids. Primarily liquid nitrogen is commonly used for storing laboratory samples and/or components; liquid helium may be used for cooling superconductor magnets. They are extremely cold while in a compressed, liquid state. In their gaseous state, they are inert, colorless, odorless, noncorrosive and nontoxic.

⚠️ ALERT Liquid nitrogen contact with skin may cause serious freezing (frostbite) injury. Wear cryoprotective (insulated) gloves at all times when working with cryogenic liquids.

When liquid nitrogen or helium are dispensed they release gases, which are simple asphyxiants (displace oxygen). Displacing oxygen creates the potential for a hazardous oxygen deficiency. OSHA specifies that a hazardous atmosphere may include one where the oxygen concentration is below 19.5% or above 23.5%.

The following are some of the most common locations where cryogenic liquids are found—and potentially creating an oxygen deficient atmosphere:

- Magnetic Resonance Imaging (MRI) rooms (or magnet rooms)
- Liquid Nitrogen Tanks (freezer farms)
- Transmission Electron Microscope (TEM) rooms

Oxygen monitoring devices may be needed in these areas to continuously monitor oxygen levels where cryogenic liquids are stored. To determine if an oxygen monitoring device is needed in your location, call the DOHS for an assessment at (301) 496-2960. These devices require preventive maintenance and calibration on an annual basis, or as specified by the manufacturer. There is also a DOHS protocol for using these devices.

Oxygen monitoring devices:

- Are typically installed in locations where compressed gases or cryogenic liquids are stored and/or dispensed in a manner that would create the potential for displacement of oxygen.
- May be required by the NIH Design Requirements Manual for Biomedical Laboratories and Animal Research Facilities.
- Alarm occupants of dangerously low oxygen levels.
- Must be serviced and maintained by the NIH Institute or Center, including calibration every six months (or more frequently if recommended by the manufacturer).

⚠️ ALERT If the device alarms, call 911 (off campus call 9-911) to have the Fire Department verify oxygen levels.

Cryogenic Solids

Dry ice is a cryogenic solid and should be treated in a manner different than regular ice. Dry ice is extremely cold, solid CO₂ and is a simple asphyxiant. Safety measures for handling and transporting the material include:

- Wear protective clothing. Use insulated gloves that are made of a thick material; also wear proper clothing (long-sleeves and pants) to be sure that no skin is exposed.
- If possible, use tongs instead of your hands to pick up dry ice.
- Handle the dry ice in a well-ventilated room and NEVER use dry ice in a cold room.
- Do not place dry ice in an airtight container; the pressure caused by the dry ice sublimating may cause the container to explode or rupture.
- Do not dump dry ice down the drain as it may damage the sink or plumbing; allow it to sublimate at room temperature, ideally in a CFH or local exhaust device.



Liquid nitrogen tank



Chemical Fume Hoods And Other Local Exhaust Ventilation

The best way to prevent or reduce exposure to hazardous airborne chemicals is through the use of ventilation systems. Local exhaust ventilation (LEV) provides containment of airborne hazards at the source and directs contaminated air away from the work area.

All LEV must be certified by DOHS when installed and on an annual basis.

A chemical fume hood is a ventilated enclosure in which gases, vapors and fumes are exhausted. A fan on the roof of the building pulls air and airborne contaminants through the hood and ductwork and exhausts them to the atmosphere.

TIP Place a shallow shelf at the back of the hood to hold supplies while allowing proper ventilation

The front sash provides protective shielding and maximizes hood performance by optimizing the velocity of the air through the front. Keep the sash at the appropriate level (as indicated by the green sticker) to ensure optimal face velocity. Improper positioning of the sash can result in turbulence and loss of containment.

The baffles direct the air being exhausted, and in many hoods, they can be adjusted to improve performance. It is important that the baffles are not closed or blocked since this blocks the exhaust path.

NOTE When working with heavy vapors such as halogenated solvents, consult with DOHS for optimal adjustment of the baffles.

The airfoil or beveled frame around the hood face provides more even airflow into the hood by avoiding sharp curves that can create turbulence.

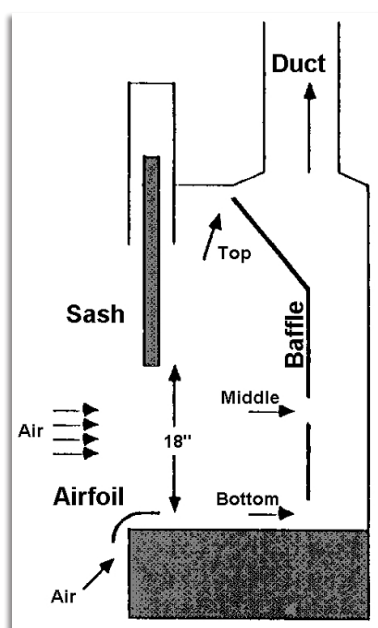
Class II Type B biosafety cabinets provide protection from biohazardous material as well as small quantities of potentially hazardous

vapor-producing chemicals. Air is pulled through the cabinet and a HEPA filter and exhausted outside the building. **If considering a Type B biosafety cabinet for your work, contact DOHS (301-496-2960) to discuss suitability.**

Downdraft Tables. Like chemical fume hoods, downdraft tables exhaust air to the outside atmosphere. Unlike chemical fume hoods, the blower is usually mounted below the work area so that air is pulled down through a perforated surface and then exhausted to the outside. Downdraft tables are used for applications involving heavier-than-air gases and materials such as anesthetic gases and histological chemicals.

Other Local Exhaust Ventilation, (e.g., slot hoods, snorkels and cage changing tables) must be certified when installed and on an annual basis.

NOTE Ductless CFHs are not permitted to be used in NIH laboratories. Captured organic vapors may desorb from the charcoal filters, resulting in capture failure.



Airflow through properly functioning CFH



Use a tissue to check for proper airflow.



Downdraft table



Class II Type B biosafety cabinet

Negative Airflow

In any laboratory where hazardous materials are handled, the air must flow from outside of the laboratory into the laboratory. It is critical to keep doors closed to maximize ventilation efficiency. The laboratory's negative airflow serves as a secondary barrier to chemical hazards by keeping hazardous airborne particles and noxious odors inside the laboratory.

Cold Rooms

Overview

Cold rooms have closed air-circulation systems and re-circulate any vapors from spills and leaks within the chamber.

The refrigeration coils in cold rooms are aluminum and subject to damage from corrosive atmospheres.

Electrical equipment used in cold rooms:

- Should have Ground Fault Circuit Interrupter (GFCI) protection, as cold rooms are often damp.
- Should be plugged directly into an outlet. Do not use extension cords.
- Should be allowed to equilibrate prior to use after removal from a cold room, as condensation can occur.

Cold Room Chemical Hazards

Compressed gas, dry ice and liquid nitrogen can pose an asphyxiation hazard by displacing oxygen and should never be used or stored in a cold room.

Flammable chemicals can release sufficient vapors to form explosive atmospheres. Cold rooms have fans and electrical equipment that are potential ignition sources.

Noxious fumes may be released by materials that have been heated on a hot plate. Only use stir plates (not hot plates) in the cold room.

Recommendations for Cold Room Work

Ensure door release mechanisms are working and doors are free of obstructions.

Avoid working alone. If you must work alone, have someone contact you periodically.

Ensure that shoes have no-slip soles; water and ice are common in cold storage and pose slip and trip hazards.

Dress appropriately: layer clothing for warmth and wear insulated gloves to protect your hands.

NEVER store flammables, dry ice, or hazardous liquid chemicals in the cold room.

It is critical to keep doors closed to maximize ventilation efficiency.

Avoid mold contamination by keeping cardboard or other paper products out of the cold room.



Prevent Asphyxiation

No fresh air circulates in this cold room!

NO hazardous chemicals, pressurized gases or dry ice

Avoid Mold Contamination

Preserve your health and scientific data!

NO food, drink, cardboard or other paper products

Maintain Equipment Integrity

Prevent rust and corrosion!

AVOID moisture build-up; keep the door closed

AVOID cluttering and trash accumulation

CLEAN UP all spilled materials immediately



NO Hazardous Chemicals



NO Pressurized Gases



NO Dry Ice



NO Food or Drink



NO Cardboard or Other Paper Goods



DO Clean up spills & dispose of trash

PPE General Guidelines

Using personal protective equipment is often essential, but it is generally the last line of defense after engineering controls, work practices, and administrative controls.

Minimum Protection

All persons working in the lab should have clothes that cover their legs and arms, and closed-toe shoes. **When handling hazardous chemicals, safety glasses with side shields, and laboratory coats must be worn.** This is minimum protection and must be upgraded as appropriate for the risk.

Additional PPE

Additional PPE must be worn if indicated by the potential exposure, such as:

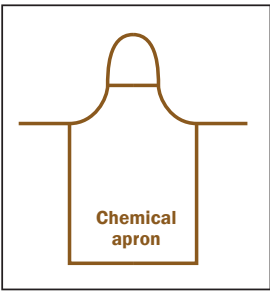
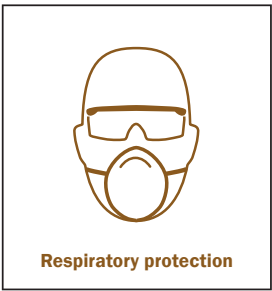
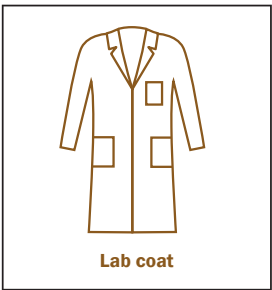
- splash goggles,
- face shields,
- chemical aprons,
- disposable coveralls,
- chemically resistant gloves,
- respiratory protection, and
- chemical resistant footwear.

Factors to consider are the type of potential chemical, length and route of exposure, and type of contact (splash, mist, vapor, occasional or continuous immersion). Contact a DOHS Safety Specialist for assistance in selecting appropriate gloves and respiratory protection. The use of respiratory protection requires an industrial hygiene hazard assessment and a medical clearance by OMS, followed by a fit test and training by the DOHS TAB.

Chemically Resistant Gloves

Gloves must be selected on the basis of their chemical resistance to the material(s) being handled, their suitability for the procedures being conducted, their resistance to wear as well as temperature extremes. Consult the Glove Selection section for detailed guidance for selecting chemically resistant gloves, or contact your DOHS Safety Specialist.

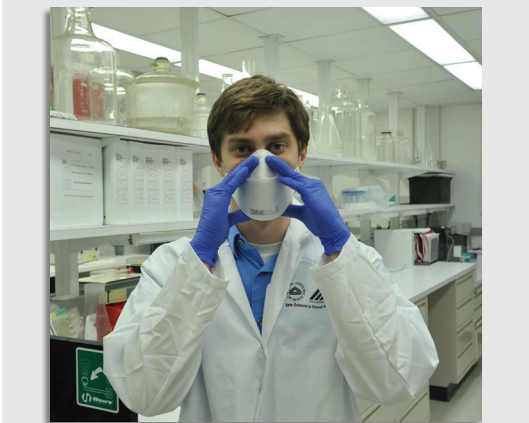
CAUTION: Improper selection may result in glove degradation, penetration of the chemical through the glove, and ultimately exposure to the chemical.



Lab coats and safety glasses provide minimum protection.



Wear additional PPE as needed.



Contact DOHS for respiratory protection selection and fit-testing

Lab Coat Selection

Lab Coat Selection and Use:

- **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** weekly or earlier if contaminated; use commercial laundry only.
- **Cuffed sleeves** prevent exposure to wrists and arms.
- **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 synthetic material** resist ignition but once ignited will melt and can cause severe localized burns.
- **Blended fabrics** often have a high rate of burning combined with fabric melting.

Reusable lab coats should be cleaned and dried when contaminated, and replaced when damaged.

Use only fire-retardant lab coats with pyrophoric or highly flammable chemicals.

Follow lab coat supplier’s instructions for laundering and replacement.

Consider heavy-duty materials such as Tychem® for chemical contact. Tychem® is a Tyvek® fabric coated with polyethylene and provides protection against minor chemical spills and splashes.

-  **ALERT**
- **In most cases, lab coats will need to be supplemented with additional protective equipment.**
 - **Lab coats should extend to the knees and be fully buttoned with sleeves rolled down.**
 - **Don’t wear lab coats in public places, such as offices, lunchrooms, or lounge areas, as they can transfer hazardous materials and contaminate these areas.**
 - **Tyvek® coveralls can be used over street clothes for protection against particles, but provide limited protection against liquids, but do not provide sufficient protection against liquids.**
 - **Cotton lab coats are preferred over polyester as they are more flame-resistant and breathable.**



Fabric Type	Uses
Polyethylene (disposable)	Liquid resistant for high-hazard biological materials, such as Biosafety Level 3 if the potential for a splash exists
Cotton	All-purpose
Polypropylene	General bench work
Cotton/poly blend	General bench work
Fire-retardant or heavy duty tightly woven cotton	Pyrophoric or highly flammable
Chemically resistant apron	Select based on anticipated chemical exposure
Spunbonded olefin such as Tyvek®	Biological or particulate, clean rooms

Glove Selection

Glove Selection and Use:

- All gloves are permeable and the changes are not always apparent.
- Visible degradation of gloves 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 provide adequate dexterity and comfort).
- Reusable gloves can be used for intermittent chemical work. They must be properly rinsed and air dried. Always inspect reusable gloves for integrity before use.
- Disposable gloves provide barrier protection for small amounts of chemicals. They should be replaced immediately when contaminated, and never be reused.
- Glove liners may be reused, but must be replaced when contaminated.
- Latex deteriorates quickly when exposed to petroleum products.
- Surgical latex gloves are thicker than latex exam gloves.

-  **ALERT** Factors to consider when choosing a chemical resistant glove:
- frequency and duration of chemical contact
 - nature of contact (immersion and/or splash)
 - concentration of chemical
 - chemical compatibility
 - temperature of chemical
 - abrasion-resistance requirements
 - puncture, snag, tear, and cut-resistance
 - length of hand and arm to be protected
 - dexterity requirements
 - grip requirements and conditions (e.g., wet or oily)
 - thermal protection - to protect against heat and cold
 - size
 - comfort

Always consult the manufacturer’s glove selection guidelines, and your DOHS Safety Specialist for help in selecting the appropriate glove.

Consider Using:

- **Knit glove liners** to absorb perspiration
- **Extended cuffs** to protect wrists and forearms
- **Ultra-thin gloves** to provide greater tactile sensitivity
- **Textured finishes** to provide better grip



Glove Type	Uses
Disposable: vinyl, latex, nitrile	Dry powders, aqueous solutions
Reusable: Neoprene	Corrosives, solvents and alcohols; Resists oils and offers less fatigue
Reusable: Nitrile	Organic solvents (non-halogenated); Puncture and abrasion resistant
Reusable: Nomex® or Zetex®	Temperature extremes
Reusable: Butyl	Aldehydes, ketones and esters
Reusable: Viton®	Chlorinated and aromatic solvents

Contact

Division of Occupational Health and Safety
Office of Research Services
National Institutes of Health
U.S. Department of Health and Human Services

Building 13, Room 3K04
13 South Drive , MSC 5760
Bethesda, MD 20892-0003
Telephone: (301) 496-2960
Fax: (301) 402-0313
<http://www.ors.od.nih.gov/sr/dohs>



Useful Websites

National Library of Medicine Gateway

<http://gateway.nlm.nih.gov/gw/Cmd>

Agency for Toxic Substances and Disease Registry

<http://www.atsdr.cdc.gov/index.html>

TOX-NET

<http://www.toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?TOXLINE>

NIOSH Pocket Guide to Chemical Hazards

<http://www.cdc.gov/niosh/npg/search.html>

OSHA Laboratory Standard – Safety & Health Topics

<http://www.osha.gov/SLTC/laboratories>

OSHA Hazardous & Toxic Substances

<http://www.osha.gov/SLTC/hazardoustoxicsubstances/index.html>

Chemical Safety Board – Video on Lab Accidents, “Experimenting with Danger”

<http://www.csb.gov/videoroom/detail.aspx?VID=61>

Argonne National Labs

http://www.aps.anl.gov/Safety_and_Training/User_Safety/gloveselection.html

DrugBank

<http://www.drugbank.ca/>

Sigma-Aldrich

http://www.sigmaaldrich.com/Area_of_Interest/The_Americas/United_States.html

Physicians’ Desk Reference (PDR) Health

<http://www.pdrhealth.com/home/home.aspx>

Chemical Compatibility Chart

http://www.ehs.harvard.edu/sites/ehs.harvard.edu/files/chemical_waste_chemical_compatibility_chart.pdf

NIH personal Property Management Guide

<http://oma.od.nih.gov/manualchapters/acquisitions/26101-25-2/26101-25-2.pdf>

Dangerous Practices: True Stories

We are the authors of our own disasters.

~Latin proverb

Inadequate personal protective equipment

A scientist spilled a drop of dimethyl-mercury, possibly more, on her gloved hand. She died less than a year later. Tests showed subsequently that the dimethyl-mercury would have penetrated the glove and started entering her skin within 15 seconds. It is now accepted that the only safe precaution to take when handling this compound is to wear highly resistant laminated gloves underneath a pair of long-cuffed neoprene (or other heavy duty) gloves.

Improper chemical handling

A research assistant was using a plastic syringe to extract a small quantity of t-butyl lithium – a chemical compound that ignites instantly when exposed to air – from a sealed container. As she withdrew the liquid, the plunger came out of the syringe, igniting a flash fire which set her synthetic sweater ablaze and spread second- and third-degree burns over 43% of her body. She died 18 days later. Two months earlier, safety inspectors found more than a dozen deficiencies in the same lab.

Scaling up without review

A student received severe burns and lacerations to his face and hands while synthesizing an energetic material, nickel hydrazine perchlorate. Despite being told by his adviser to make no more than 100 mg of the material, the student attempted to synthesize 10 g in the open lab without the protection of a blast shield. Disastrously, the mixture detonated, resulting in serious injuries, including the loss of 3 fingers.

Improvised equipment

Four students were injured in a hydrogen explosion in a university biochemistry lab. The explosion occurred during a routine setup of a microbiological anaerobic growth chamber. Normally, nitrogen is first introduced to purge the air (~20% oxygen) from the chamber before hydrogen is introduced. However, a T-connection without a toggle switch was being used temporarily, and the hydrogen had been inadvertently introduced into the chamber simultaneously with nitrogen, creating an explosive atmosphere.

Improper chemical waste disposal

An explosion occurred in an organic chemistry lab and the local fire department responded. Two students received first- and second-degree chemical burns and were taken to an area burn unit. The evidence was consistent with waste material (strong acids) being inappropriately added to an organic reagent bottle and not to a chemical waste container, resulting in rapid oxidation.