

Chemical Safety Guide

Indian Institute of Technology
Hyderabad

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1. hazard identification

The Globally Harmonized System of classification and Labelling of Chemicals (GHS) provides an international Standardized approach to the classification and labelling of chemicals. The occupational Safety and Health Administration (OSHA) Hazard Communication Standard (HCS) aligns with the GHS to ensure consistency of information.

The HCS requirements include:

A. Hazard Classification: provides specific criteria for classification of Health, physical and environmental hazards, as well as classification of mixtures.

B. 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.

C. Safety Data Sheets (SDS): previously called Material Safety Data Sheets (MSDS), have a specified 16 section format.

D. 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’

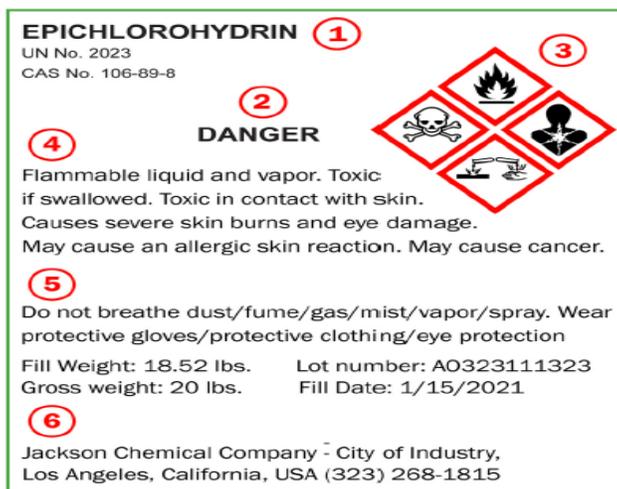
GHS Pictograms:

| | | |
|---|---|---|
| <p>HEALTH HAZARD</p>  <ul style="list-style-type: none"> • Carcinogen • Mutagenicity • Reproductive Toxicity • Respiratory Sensitizer • Target Organ Toxicity • Aspiration Toxicity | <p>FLAME</p>  <ul style="list-style-type: none"> • Flammables • Pyrophorics • Self-Heating • Emits Flammable Gas • Self-Reactives • Organic Peroxides | <p>EXCLAMATION MARK</p>  <ul style="list-style-type: none"> • Irritant (skin and eye) • Skin Sensitizer • Acute Toxicity (harmful) • Narcotic Effects • Respiratory Tract Irritant • Hazardous to Ozone Layer (Non-Mandatory) |
| <p>GAS CYLINDER</p>  <ul style="list-style-type: none"> • Gas Under Pressure | <p>CORROSION</p>  <ul style="list-style-type: none"> • Skin Corrosive/Burns • Eye Damage • Corrosive to Metals | <p>EXPLODING BOMB</p>  <ul style="list-style-type: none"> • Explosives • Self-Reactives • Organic Peroxides |
| <p>FLAME OVER CIRCLE</p>  <ul style="list-style-type: none"> • Oxidizers | <p>ENVIRONMENTAL (NON-MANDATORY)</p>  <ul style="list-style-type: none"> • Aquatic Toxicity | <p>SKULL AND CROSSBONES</p>  <ul style="list-style-type: none"> • Acute Toxicity (fatal or toxic) |

indicating the more severe hazard. The appropriate signal word is determined by the hazard classification.

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



Once the chemical delivered to the supplier lab member should not obscure or remove any of the label elements from the container. If the chemical is transferred into the different container, the name of the chemical and any associated hazards must also be placed on the container; the label must be in English and prominently displayed on the container.

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).

Secondary Container/ Solution Labeling

Secondary container labeling is required in the following instances:

- When the secondary container will be used for longer than one working day.
- When the person who transferred the chemical leaves the work area.
- When the person who transferred the chemical takes it to an alternate location where they are no longer in direct possession of the chemical.

This labeling requirement includes **flasks, beakers, spray bottles** and **test tubes containing chemicals**. If the chemical will not leave the supervision of the person who transferred it during one workday, complete secondary container labeling is not required.

Full secondary container labeling includes the following:

- Name of the chemical (English Language)
- Hazard warning
- Date of transfer to secondary container

- Preparer's name
- Expiry Date (if applicable).

SAFETY DATA SHEETS (SDS)

Safety Data Sheets have replaced Material Safety Data Sheets (MSDS) under the Globally Harmonized System. The present details of the chemical hazards in a standardized format to improve clarity and comprehension.

The SDS includes the following in this order:

1. Identification
2. Hazard 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

2. Hazard Control/Hazardous Spill Procedure

Hazard Assessment

A chemical hazard assessment identifies the hazard of the chemical and processes used in the laboratory. The assessment evaluates the potential for risk and the severity of the risk associated with the chemical hazard. The assessment determines measures to eliminate, minimize, or control the hazard and potential risks.

What needs to be done?

To perform a chemical hazard assessment, laboratory workers should examine their plan for the experiment and identify any chemicals with which they are not familiar. The SDS for each unfamiliar chemical should be reviewed. SDS should be maintained by the laboratory in certain locations (common place), in such a way all lab members are accessible as 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.

What does this entail?

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

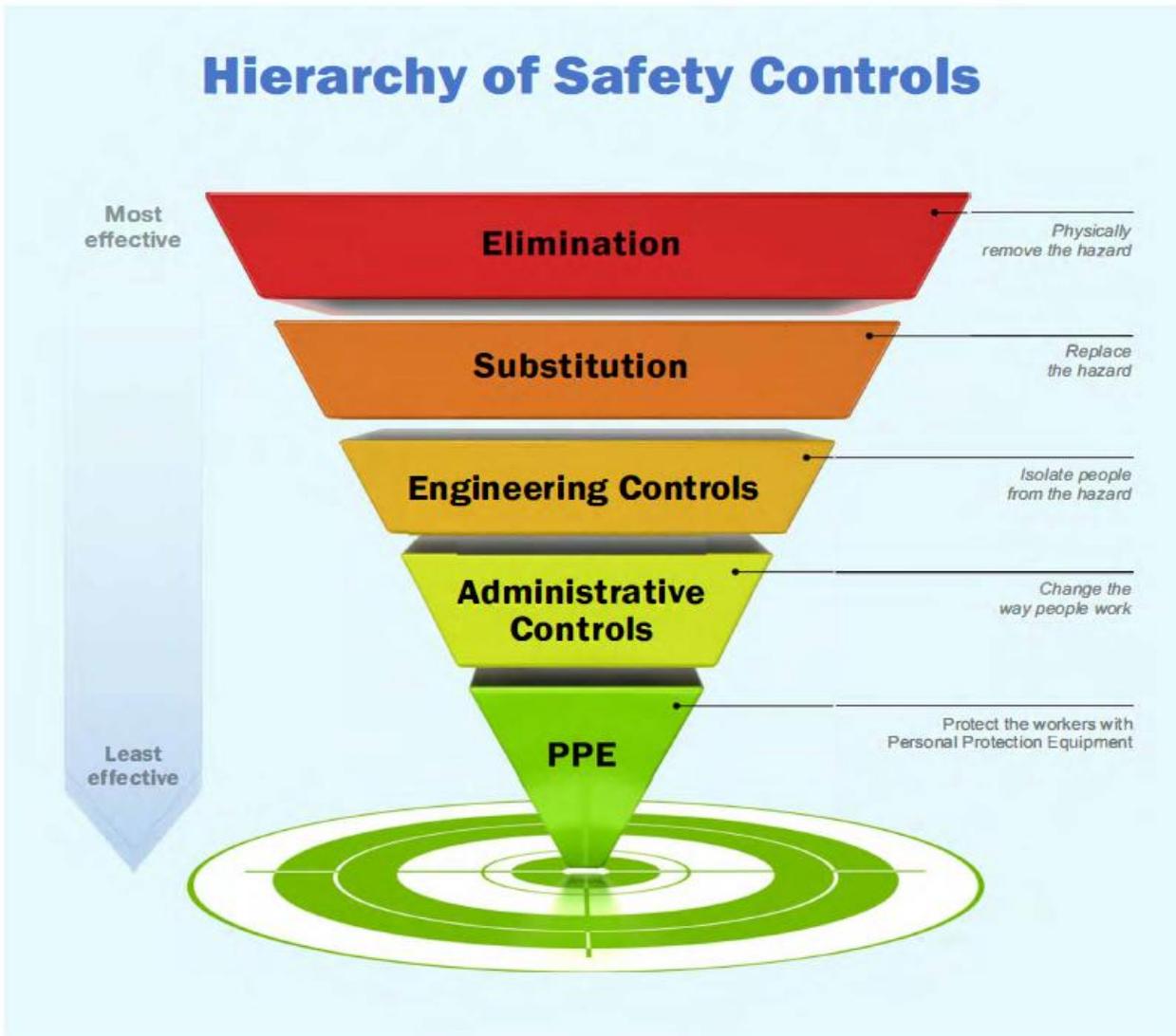
1. SDS for the chemical or reagent
2. Description of work/activities/use
3. Storage requirements
4. Disposal and environmental requirements
5. Health Surveillance
6. First aid/emergency procedures
7. Proposed controls, to include.
 - a. Elimination
 - b. Substitution
 - c. Engineering controls
 - d. Administrative controls
 - e. Personal Protective Equipment
8. A specific written chemical standard operating procedure (SOP) is required for particularly Hazardous Substances (PHS).

Template of the specific chemical hazard and lab-specific chemical SOP

The Specific Chemical Hazard SOP is used to outline the hazards of a chemical and to describe general procedures for working with it. The Lab-Specific Chemical SOP is used to outline the chemical hazards of a specific procedure/experiment and to elaborate on the specific protocol to be used during the procedure/experiment. Both SOPs can be used for PHS and non-PHS chemicals.

| STANDARD OPERATING PROCEDURES (SOPs) | | | |
|--|-------------------|-----------------------|---------------------|
| Title: Specific Chemical Hazard Template | | | |
| Document No. | Document Page(s): | Author's Branch: | Effective Date: |
| Revision: | Revision Date: | Reviewed/Approved by: | Date: |
| Overseeing Official's Signature: | | Date: | Procedure Location: |
| Instructions for filling out your SOP | | | |
| <p>This template is intended to be filled out with information on chemical hazards within the laboratory. The purpose is to generate a chemical-specific standard operating procedure which is to be followed by each individual handling or potentially exposed to the given chemical. To fill out this template:</p> <ul style="list-style-type: none">• Section 1: Use information from the chemical safety data sheet (SDS)• Section 2: Describe the lab-specific procedure(s) the chemical is used in• Section 3: Attach the SDS for the chemical to this SOP• Section 4: Enter information on the ventilation controls used and/or any alternatives to standard ventilation controls• Section 5: List the PPE that will be worn when working with the chemical. Ensure that any PPE listed is compatible with the chemical.• Section 6: Fill out information on the preparation, usage, storage, and transport of the chemical. Add details for lab-specific procedures.• Section 7: Fill in specific details for spill procedures. Include information such as the location of spill kits, the specific materials that must be used, PPE that must be worn, or specific procedures that must be followed during spill cleanup.• Section 8: No action necessary.• Section 9: Fill in information on waste disposal – customize to the specific procedure and chemical.• Section 10: No action necessary.• Section 11: Fill in information on decontamination and designated work location for the chemical.• Section 12: Document training for all personnel who will handle this chemical. All personnel must sign to indicate they are aware of the hazards and of all general and lab-specific procedures which must be followed when using this chemical. | | | |

| STANDARD OPERATING PROCEDURES (SOPs) | | | |
|--|--|-----------------------|---------------------|
| Title: Specific Chemical Hazard Template | | | |
| Document No. | Document Page(s): | Author's Branch: | Effective Date: |
| Revision: | Revision Date: | Reviewed/Approved by: | Date: |
| Overseeing Official's Signature: | | Date: | Procedure Location: |
| 1 PURPOSE OF STANDARD OPERATING PROCEDURE | | | |
| <input type="checkbox"/> Specific Laboratory procedure or experiment [Examples: synthesis of chemical luminescent esters, folate functionalization of polymeric micelles, etc.] <input type="checkbox"/> Generic laboratory procedure that covers several chemicals [Examples: distillation, chromatography, etc.] <input type="checkbox"/> Generic use of specific chemical or class of chemicals with similar hazards [Examples: organic azides, mineral acids, etc.] | | | |
| 2 DESCRIPTION OF PROCESS/EXPERIMENT | | | |
| <i>[Provide a brief description of your process or experiment, including its purpose. Do not provide a detailed sequential description as this will be covered by section #6 of this template. Indicate the frequency and duration below.]</i> | | | |
| Frequency | <input type="checkbox"/> one time <input type="checkbox"/> daily <input type="checkbox"/> weekly <input type="checkbox"/> monthly <input type="checkbox"/> other: _____ | | |
| Duration per experiment: | _____ minutes; or _____ hours | | |
| 3 SAFETY LITERATURE REVIEW AND HAZARD SUMMARY | | | |
| 1. Hazardous Substances <i>[List hazardous substances and their associated health and safety hazards. Examples of potential hazards include toxicity, reactivity, flammability, corrosivity, pressure, etc. Refer to Safety Data Sheets (SDSs) and other resources, as needed.]</i> | | | |
| 2. Other Hazards <i>[List nonchemical hazards, e.g., biological hazards, electrical hazards, physical hazards, (including sharps), mechanical hazards, nonionizing radiation, or ionizing radiation.]</i> | | | |



Control Exposure

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

If the hazard cannot be eliminated, other hazard control methods must be used. Personal Protective Equipment (PPE) should never be the only method of choice to reduce the exposure.

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

Administrative Control:

1. Ensure personnel are adequately trained for the chemicals and associated processes.
2. Never pipette by mouth.
3. Transport laboratory chemicals using bottle carriers, secondary containment, and/or suitable carts.
4. Follow the established procedures for the decontamination and movement of scientific and medical equipment.
5. In the event of a hazardous chemical spill, immediately follow the hazardous material spill procedure.
6. Store all food, beverages, cosmetics, and medications outside the lab.
7. Keep all doors to the laboratory closed to ensure proper fume hood performance and directional airflow into the lab.
8. Ensure unimpeded access to safety showers, eyewash stations and exit pathways.
9. Check and flush eyewash stations weekly document the date and initials of the individual who performed the test.
10. 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.
- Do not wear PPE outside the laboratory.
- Upon completion of work, remove gloves carefully and thoroughly wash hands and forearms before leaving the laboratory.
- Dispose of used gloves properly.
- Wear eye protection when a splash potential exists.



Engineering Control: Chemical Fume Hood



Administrative Control: SOP, Policies and Guidelines



PPE: Gloves & Goggles

Spill Prevention:

Most spills are preventable. The following tips could help prevent or minimize the spill.

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

3. Storage, Handling and Transport

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:

1. Ensure all hazardous chemicals are properly labeled.
2. Record the date of receipt on each bottle to assist with inventory management.
3. Record the date of opening on each chemical and dispose prior to the expiration date.
4. Upon preparation, label and date solutions with the chemical or mixture name, as well as any applicable hazard warnings.
5. Store incompatible chemicals separately by hazard class. Within a hazard class, chemicals may be stored alphabetically.



6. Store flammable and combustible materials in an approved storage cabinet. Flammable should be stored away from chemical fume hoods and biological safety cabinets.
7. Containers of 500 ml or less flammable of current day working stock may be stored outside a flammable cabinet.
8. Always store hazardous chemicals no higher than eye level and never on top of a storage unit. Keep the storage cabinet door closed.
9. Do not overcrowd shelves.
10. Do not store chemicals on the floor.
11. Store acids in a dedicated acid cabinet, preferably in the ventilated storage area beneath the chemical fume hood.
12. Nitric, perchloric, chromic and sulfuric acids are strong oxidizers and must be kept isolated from organic acids.
13. Store bases in a corrosive cabinet.
14. Store highly toxic materials in a closed, dedicated poison cabinets.
15. Chemicals to be stored in a refrigerator or freezer must be in units appropriately rated for hazardous material storage.

16. NEVER store hazardous chemicals in a cold room or other storage area with recirculating ventilation.
17. Do not store hazardous chemicals under the sink.
18. Secure all compressed gas cylinders. Keep protective caps on cylinders when not in use (including during transport). Remove empty cylinders as soon as possible.
19. Store chemicals away from heat and direct sunlight.
20. Rotate chemical inventory. Dispose of chemicals by their expiry date.
21. Inspect chemical containers regularly for deterioration and integrity.
22. Store chemicals under appropriate conditions. Chemicals are stable only when stored in an inert gas such as nitrogen. Certain chemicals may burst into flames when exposed to air or moisture in the air.
23. Consult Lab in charge or safety specialist before working with chemicals that are new or unfamiliar.

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

Consideration 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.
- Place chemicals in sturdy secondary containers.

Chemical Transport

Moving Chemicals within the laboratory

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

Do not tighten, open or move containers that have crystals forming on the caps and seals or inside the bottle.



Use carts or bottle carriers to move chemicals short distances.



Place the chemicals in sturdy secondary containers.



Chemical Waste Disposal

Waste disposal procedures are described in the IITH website. Adhere the procedures whenever dispose of the waste as notified by the Safety office.

DON'T

- Don't mix incompatible chemicals
- Don't discard chemicals in sinks or general trash.
- Don't dispose of volatile chemicals by evaporation.
- Don't put waste containers in hallways or public locations adjacent to lab sides, back of departments any other place.
- Don't move chemicals with precipitation on or in the bottle.

DO:

- Keep waste containers always closed.
- Store waste in the laboratory while awaiting pick up.
- Store all the liquid waste containers leak proof containers.
- Dispose chemical waste during the collection time.
- Attach a complete composition in the waste tag.
- Consider an annual chemical clean-up day to dispose of old or unwanted chemicals.
- Segregate ACIDS and BASES, whether DRY or LIQUID when collecting chemicals for picking up or cleaning up the laboratory.
- Collect solvent or solvent mixture separately do not mix with acid or bases.
- Solid waste collected and labeled as solid waste in the waste tag.
- Affix a chemical waste tag in each box, identifying the content.
- Get signature of PL in the chemical waste requisition form and submit before collecting the chemical waste to the Departmental Nominee.



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.

Highly Reactive Chemicals

Highly Reactive chemicals include those which are inherently unstable and susceptible to rapid decomposition.

The 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 chloride 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 an 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.

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.

Suggested Storage Time limits for Common Peroxide Forming Compounds

| CLASS A: MOST DANGEROUS | CLASS B: DANGEROUS | CLASS C: DANGEROUS |
|--|--|---|
| Chemicals that can form explosive levels of peroxides during storage without concentration. | These chemicals are a peroxide hazard during storage and on concentration (distillation/evaporation). A test for peroxide should be performed if concentration is intended or suspected. | Unsaturated monomers that may auto-polymerize as a result of peroxide accumulation if inhibitors have been removed or are depleted. |
| <i>Discard after 3 months.</i> | <i>Inspect every 6 months following date of opening</i> | <i>Inspect every 6 months following date of opening</i> |
| Isopropyl ether Butadiene Chlorobutadiene (chloroprene) Potassium amide Potassium metal Sodium amide Tetrafluoroethylene Divinyl acetylene Vinylidene chloride | Acetal Cumene Cyclohexene Cyclooctene Cyclopentene Diacetylene Dicyclopentadiene Diethyl ether Diethylene glycol dimethyl ether | Dioxane Ethylene glycol Furan Methyl acetylene Methyl cyclopentane Methylisobutyl ketone Tetrahydrofuran Tetrahydronaphthalene Vinyl ethers |
| | | Acrylic acid Butadiene Chlorotrifluoroethylene Ethyl acrylate Methyl methacrylate Styrene Vinyl acetate Vinyl chloride Vinyl pyridine |

4. Special Hazards

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.

What are Particularly Hazardous Substances (PHS)?

PHS are chemicals that may pose extreme hazards to laboratory employees.

PHS include substances with a high degree of acute toxicity, reproductive toxins, and select carcinogens (those strongly implicated as a potential cause of cancer in humans and/or those regulated by OSHA and NIH).

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.

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 PHS 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.

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 dust or aerosols formed? Is it heated or concentrated?

Is this a reproductive hazard? Reproductive hazards are substances or agents that may affect the reproductive health of women or men or the ability to have healthy children. OMS may be consulted by all

staff of reproductive capability (i.e., women, men, those who are pregnant, planning to become pregnant, or breastfeeding) when there is a concern for past exposure or potential future exposure to a reproductive hazard(s).

Do any employees have 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.

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 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.

Store cylinders in cool, well-ventilated, fire-resistant areas in compliance with local, state, and federal regulations.

Separate flammable gases from oxygen by a minimum distance of 20 feet.

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, capped, 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. Cold rooms are built to be closed systems without ventilation and expose the user to risk of asphyxiation if compressed gases are used.

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 the soap bubble test.

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. Liquid nitrogen (LN₂) is commonly used for storing laboratory samples and/or components; liquid helium may be used for cooling superconducting magnets.

Both are extremely cold (-195.8 °C/-384.4 ° F for nitrogen and -268.9 ° C/-516 ° F for helium) while in a compressed, liquid state. In their gaseous state, they are inert, colorless, odorless, noncorrosive and nontoxic.

Cryogen contact with skin may cause serious freezing (frostbite) injury. Wear cryoprotective insulated gloves when working with cryogenic liquids. Cryogenic gloves used in research are not designed/rated to protect against immersion into cryogenic liquids or prolonged handling of cryogenically chilled materials.

When liquid nitrogen or helium are dispensed, they release gases, which act as simple asphyxiants and displace oxygen. Displacing oxygen creates the potential for a hazardous environment.

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, potentially creating an oxygen deficiency atmosphere:

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

Cryogenic Solids/Dry Ice

Dry ice is a cryogenic solid that should be treated in a manner different than regular ice.

Dry is extremely cold, solid CO₂ and is a simple asphyxiant.

Safety measures for handling and transporting the material include:

- Wear protective clothing.
- Use 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 while wearing gloves instead of your properly gloved 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 or if unavailable, in a large well-ventilated space.

5. Ventilation Strategies

Chemical Fume Hoods and other Local Exhaust Ventilation

The best way to prevent or reduce exposure to hazardous airborne chemicals is using ventilation systems.

Local exhaust ventilation (LEV) provides containment of airborne hazards at the source and directs contaminated air away from the work area.

A chemical fume hood (CFH) is a ventilated enclosure in which gases, vapor 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.

The CFH 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 mentioned by manufacturer instructions.

Improper positioning of the sash can result in loss of containment (i.e. if the sash is too high, air velocity will be insufficient, if the sash is too low, air velocity will be too high, resulting in turbulence which can force contaminants out of the hood).

All work in a CFH should be conducted at least 6" inside (past) the sash. Close the sash when the CFH is not in use.

The baffles direct the air to 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.

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

Biosafety cabinets

Biosafety cabinets provide protection from biohazardous materials as well as small quantities of potentially hazardous vapor-producing chemicals.

The air is pulled through the cabinet and a HEPA filter and exhausted outside the building.

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.

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



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

Cold rooms Cold rooms have closed air-circulation systems and re-circulating 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, liquid nitrogen and liquid helium 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, let others know you are working inside and have someone check on you periodically.
- Take a 10-minute break every 50 minutes while working inside the cold room.
- 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.
- Include emergency contact information posted outside of the cold room.



Prevent Asphyxiation

No fresh air circulates in a cold room!

NO hazardous chemicals, pressurized gases or dry ice

NO food, drink, cardboard or other paper products

Maintain Equipment Integrity

Prevent rust and corrosion!

AVOID moisture build-up; keep the door closed

CLEAN UP all spilled materials immediately



NO Hazardous Chemicals



NO Pressurized Gases



NO Dry Ice



NO Food or Drink



NO Cardboard or Other Goods



DO Clean up spills & dispose of trash

6. Personal Protective Equipment (PPE)

PPE 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 the people working in the lab should have clothes that cover their legs and arms and closed-toe shoes.

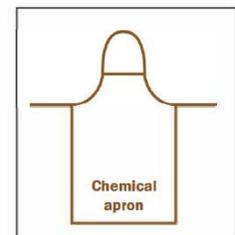
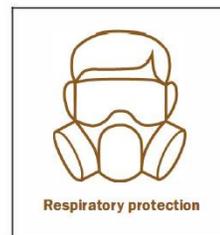
When handling hazardous chemicals, appropriate eye protection, appropriate gloves and laboratory coats must be worn.

This is the minimum protection required and must be upgraded as appropriate for the risk.

Additional PPE

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

- Splash goggles
- Face shields
- Chemical aprons
- Disposable coveralls
- Chemical resistant gloves
- Respiratory protection
- Chemical resistant footwear



Factors to be considered use of additional PPE

Type of potential chemical, length and route of exposure

Type of contact (splash, mist, vapor, occasional or continuous immersion).

Chemical 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.

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

Lab coat selection

- Fabric weight and weave affect how easily material ignites and burns; select tight weaves, 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 materials resist ignition but once ignited it 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. Do not clean at home.
- 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 for chemical contact. They are coated with polyethylene and provide protection against minor chemical spills and splashes.
- 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 down 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.**
- Coveralls can be used over street clothes for protection against particles. However, they do not provide sufficient protection against liquids.
- Cotton lab coats are preferred over polyester as they are more breathable and flame resistant.

| Lab Coat Type | Fabric Type | Protective Use | Improper Use |
|--------------------------------------|---|---|---|
| Standard | 100% cotton (preferred for maximum protection) or cotton/polyester blend fabric (burns more readily than 100% cotton) | Minimal risk chemicals with low risk of exposure to fire. Radioactive materials, cryogenics, and lasers (general benchwork) | Moderate to high volume use of chemicals, flammables, pyrophorics when the risk of exposure to fire is high |
| Fluid/Splash and Tear Resistant | Polyethylene-coated polypropylene (disposable) | Human and animal blood and body fluids, BSL2/3 and BSL3 and bloodborne pathogens | Use with flammables and pyrophorics |
| Chemical resistant apron and sleeves | Polyethylene-coated high density polyethylene, neoprene, vinyl, pvc, polyester or polyethylene-coated polypropylene | Select chemical exposure | Use with flammables and pyrophorics |
| Nomex (Flame Resistant) | Flame resistant fabric | Flame or pyrophoric liquids and solids. Wear with a chemical apron when working with non-polar organic solvents such as acetone, dichloromethane, diethylamine, ethyl acetate, n-hexane, tetrahydrofuran, toluene | Non-flammable or pyrophoric liquids and solids |
| Spunbonded olefin such as Tyvek® | Tear resistant fabric/high-density polyethylene fibers | Biological material or particulate and clean rooms | Best at protecting against dry substances but minimal protection against liquids/splashes |

Glove Selection

- All gloves are permeable, and the changes are not always apparent.
- Visible degradation of gloves can include swelling, soft, hardening and discoloration.
- Different gloves are resistant to different chemicals.
- Multiple gloves can be worn together for greater protection (use the 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 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.

Factors to be considered 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.

| 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 | 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® | Chlorinated and aromatic solvents | Must be properly rinsed and dried after each use. |

Consider using:

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



EYE and Face Protection Selection:

- Eye protection is mandatory where there is potential for an injury.
- Eye protection must be appropriate for the type of hazard (chemical splash and vapors, impact hazards, lasers, ultraviolet light).

Safety Glasses/Spectacles:

Protect the eyes, eye sockets, and facial area surrounding the eyes from chemical hazards. They provide a seal around the eyes preventing entry under or around goggles.

Safety goggles must be fitted to the worker's face; poorly fitted goggles will not offer necessary protection.

Non-vented goggles protect eyes from vapors, mists, fumes or other hazards. Eyes must be completely covered, but the material hazard does not require covering all exposed skin.

Vented goggles protect from moderate quantities of liquids with no vapor or mist danger. Several types exist. For example, the common, hardware-store goggle has holes drilled into the plastic.

This is unsuitable for laboratory work because liquids can get through the holes. Vented laboratory goggles have a series of buttons embedded into the plastic. These buttons house a baffle plate that allows air to pass but present a physical barrier to liquids.

Face Shields: Shield the entire face from a range of hazards. Face shields are secondary protectors to be used in addition to primary protection such as safety glasses or goggles.



Face shields

Shields entire face from a range of hazards. Face shields are secondary protectors to be used in addition to primary protection such as safety glasses or goggles.

7. Chemical segregation of based on different hazard types

| Class of Chemicals | Common Chemical Examples | Additional Concerns and Storage Recommendations | Common Incompatible Chemical Types | Possible Reaction if Mixed/Health Concerns |
|--|--|---|---|---|
| Corrosive Acids-Organic  | <ul style="list-style-type: none"> Acetic acid Butyric acid Trifluoroacetic acid Propionic acid Formic acid Carbonic acid Benzoic acid | <ul style="list-style-type: none"> Store in ventilated corrosives cabinet on protected shelving using secondary containment, keep away from incompatible chemicals Do not store under the sink Do not store acids on metal shelving See compatibility chart for storage | <ul style="list-style-type: none"> Flammable liquids Flammable solids Bases Oxidizers Inorganic acids Cyanides Sulfides Poisons/toxins | <ul style="list-style-type: none"> Heat Gas generation Violent reaction DO NOT POUR WATER INTO ACID Causes skin burns Respiratory distress Use NIOSH approved gloves, eye protection, face shield and apron |
| Corrosive Acids-Inorganic  | <ul style="list-style-type: none"> Nitric acid Sulfuric acid Phosphoric acid Hydrochloric acid Hydrofluoric acid | <ul style="list-style-type: none"> Store concentrated nitric acid ($\geq 68\%$) and sulfuric acid ($\geq 93\%$) 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 Hydrofluoric acid (HF) should only be handled by trained personnel as it requires extra handling precautions. Store in a secondary container. HF is a bone decalcifier. | <ul style="list-style-type: none"> Flammable liquids Flammable solids Bases Oxidizers Organic acids Cyanides Sulfides Poisons/toxins | <ul style="list-style-type: none"> Heat Gas generation Violent reaction DO NOT POUR WATER INTO ACID Hydrofluoric acid can result in skin irritation and causes burns Respiratory distress Use NIOSH approved gloves, eye protection, face shield and apron |
| Corrosive Bases-Organic/Caustic  | <ul style="list-style-type: none"> Hydroxylamine Tetramethylethylamine Diamine Triethylamine Propylenediamine Cuprietylenediamine solution Dicyclohexylamine | <ul style="list-style-type: none"> Store in separate cabinet preferably with ventilation, corrosive cabinet or storage area with a spill tray, away from potential water sources (DO NOT store under sink) | <ul style="list-style-type: none"> Acids Oxidizers Flammable liquids/solids Inorganic bases Poisons/toxins Amines are generally incompatible with isocyanates, halogenated organics, peroxides, acidic phenols, epoxides, anhydrides, and halides | <ul style="list-style-type: none"> Heat Gas generation Violent reaction Skin irritation and burn Respiratory distress Foul odor Use NIOSH approved gloves, eye protection, face shield & apron |
| Corrosive Bases-Inorganic/Caustics  | <ul style="list-style-type: none"> Ammonium hydroxide Potassium hydroxide Sodium hydroxide Calcium hydroxide Sodium hydroxide Sodium hypochlorite solution (bleach) Magnesium hydroxide | <ul style="list-style-type: none"> Store in separate cabinet preferably with ventilation, corrosive cabinet or storage area with a spill tray, away from potential water sources (DO NOT store under the sink) Store solutions of inorganic hydroxides in labeled polyethylene containers | <ul style="list-style-type: none"> Acids Oxidizers Flammable liquids Flammable solids Organic bases Poisons/toxins | <ul style="list-style-type: none"> Heat Gas generation Violent reaction Skin burn and irritation Respiratory distress Use NIOSH approved gloves, eye protection, face shield and apron |

Chemical Segregation

| Class of Chemicals | Common Chemical Examples | Additional Concerns and Storage Recommendations | Common Incompatible Chemical Types | Possible Reaction if Mixed/Health Concerns |
|---|---|--|--|---|
| Flammable Solids  | <ul style="list-style-type: none"> Paraformaldehyde Phosphorus Magnesium Sulfur Potassium sulphide Naphthalene Camphor | <ul style="list-style-type: none"> Keep in a dry, cool area away from oxidizers and corrosives Follow specific safety procedures Conduct work on a small scale if possible Keep amounts on hand to a minimum Keep away from other flammables | <ul style="list-style-type: none"> Acids Bases Oxidizers Poisons/toxins | <ul style="list-style-type: none"> Fire hazard Violent reaction Generates toxic fumes Respiratory distress Keep away from ignition & sparks Ignites readily, burns fiercely Use NIOSH approved gloves, eye protection, face shield and apron |
| Flammable Liquids  | <ul style="list-style-type: none"> Ethanol Ethyl acetate Methanol Acetone Benzene Xylene Toluene Diethyl ether Tetrahydrofuran Acetonitrile Propanol Gasoline | <ul style="list-style-type: none"> Flammable storage cabinet or refrigerator rated for flammable/hazardous storage/explosion proof Peroxide-forming chemicals must be dated upon delivery and opening (two dates) i.e., di-ethyl ether, tetrahydrofuran, furan, methyl butanol, methyl acetylene, heptanol, dioxanes, diglyme. | <ul style="list-style-type: none"> Oxidizers Acids Bases Reactive Poisons/toxins | <ul style="list-style-type: none"> Fire hazard Heat Violent reaction Watch for vapor mist Causes eye and skin irritation Keep away from ignition or sparks Use NIOSH approved gloves, eye protection, face shield and apron |
| Toxic  | <ul style="list-style-type: none"> Chloroform Cyanides Heavy metal compounds (e.g. Cadmium, Mercury, Osmium, Arsenic, Barium) Formamide Phenol Carbon tetrachloride 2-Mercaptoethanol Acrylamide Ethidium bromide Sodium azide solution | <ul style="list-style-type: none"> Store in a dark, dry, ventilated, cool area in an unbreakable chemically resistant secondary container (polyethylene) Store volatile toxic materials 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, ONLY if the cabinet has sliding doors (not swinging) Sodium azide, must be kept refrigerated | <ul style="list-style-type: none"> Flammable liquids Acids Bases Reactive Oxidizers Corrosives | <ul style="list-style-type: none"> 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 Some toxins are mutagenic and carcinogenic Review your SDS before working with toxic material Use NIOSH approved gloves, eye protection, face shield and apron |
| Explosives  | <ul style="list-style-type: none"> Picric acid (dry) Ammonium nitrate Nitro urea Trinitroaniline Benzoyl peroxide (dry) Trinitrobenzene Trinitrobenzoic acid Trinitrotoluene Urea nitrate Trinitrophenol Diazoisbutylnitrile Sodium azide (solid) | <ul style="list-style-type: none"> Store in a secure location away from other chemicals; store in an area away from friction or shock Store Picric acid in cool location or in a hazard rated fridge to prevent explosive crystallization Storage regulations DO NOT apply to binary explosives until mixed. | <p>Explosives must be stored as "STAND ALONE." They must never be stored with any chemicals of any kind</p> | <ul style="list-style-type: none"> Explosion hazard Violent reaction Heat Shock sensitive Regular inspection may be required, to check for deposits or crystallization Use spark proof tools Use NIOSH approved gloves, eye protection, face shield and apron |

Chemical Segregation

| Class of Chemicals | Common Chemical Examples | Additional Concerns and Storage Recommendations | Common Incompatible Chemical Types | Possible Reaction if Mixed/Health Concerns |
|---|---|---|--|--|
| Oxidizers  | <ul style="list-style-type: none"> • Peroxides • Nitrates • Perchlorates • Permanganates • Sodium hypochlorite (solid) • Potassium dichromate • Chlorates • Chlorites • Chromates • Bromates • Superoxides | <ul style="list-style-type: none"> • Store in secondary containment separately from combustibles and flammable materials • May explosively decompose on shock, friction, or concussion • May EXPLODE ON HEATING, to form irritating toxic fumes and gases of Benzoic Acid and Carbon Monoxide. It's a strong oxidant and reacts violently with combustible, organic and inorganic acids, and reduces materials, causing fire and explosion hazards. Attacks some forms of plastics, rubber or coatings | <ul style="list-style-type: none"> • Combustibles • Flammables • Organic materials • Reducing agents | <ul style="list-style-type: none"> • Fire hazard • Gas generation • Toxic gas • Explosion hazard • Forms irritating toxic fumes • Use NIOSH approved gloves, eye protection, face shield & apron |
| Peroxide Formers  | <ul style="list-style-type: none"> • 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 or aldehydes (e.g. acetaldehyde, benzaldehyde) • Vinyl and vinylidene compounds • Dienes • tetrahydrofuran dioxane • Butylated hydroxytoluene (BHT) | <ul style="list-style-type: none"> • Store in airtight bottles, away from light and heat in a dark, cool dry area; 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. • 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 | <ul style="list-style-type: none"> • Always consult the Safety Data Sheet (SDS). | <ul style="list-style-type: none"> • Explosion hazard • Violent reaction • Shock sensitive • Combustion (exothermic reaction) • If an old or expired container of a peroxide-forming chemical or reactive is found, do not move it. • Use proper PPE • Use NIOSH approved gloves, eye protection, face shield & apron |
| Water Reactive  | <ul style="list-style-type: none"> • Sodium Metals • Lithium Metals • Potassium Metals • Sodium Borohydride • Alkali Metal Hydrides • Cesium Metal | <ul style="list-style-type: none"> • 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 • Do not store any other chemicals | <ul style="list-style-type: none"> • Aqueous solutions • Oxidizers • Please review the Safety Data Sheet (SDS). | <ul style="list-style-type: none"> • Heat evolution • Violent reaction when mixed with water • Liberates hydrogen gas with water • Reacts violently with water • Use NIOSH approved gloves, eye protection, face shield and apron |

Chemical Segregation

| Class of Chemicals | Common Chemical Examples | Additional Concerns and Storage Recommendations | Common Incompatible Chemical Types | Possible Reaction if Mixed/Health Concerns |
|--|--|---|--|--|
| <p>Flammable Compressed Gases</p>  | <ul style="list-style-type: none"> • Methane • Acetylene • Butane • Propane • Hydrogen • Silane • Ethane • Arsine • Germane | <ul style="list-style-type: none"> • Handle flammable compressed gases in a chemical fume hood • Store in well-ventilated areas; store away from oxidizers, open flames, sparks, and other sources of heat ignition; post NO SMOKING signs around storage area(s) or entrance(s) to storage room(s); flammable gases stored outdoors where ambient temperatures exceed 125 degrees F (51.7 degrees C) shall be protected from direct sunlight • Must be secured in upright position, bonded or chained against the wall • Use a spark proof wrench to attach regulators and make other connections; install a flame/flash arrestor at the regulator outlet flow valve | <ul style="list-style-type: none"> • Oxidizers • Toxic compressed gases | <ul style="list-style-type: none"> • Fire hazard • Explosion hazard • Use NIOSH approved gloves, eye protection, face shield and apron • Wear safety shoes |
| <p>Oxidizing Compressed Gases</p>  | <ul style="list-style-type: none"> • Oxygen • Chlorine • Fluorine • Nitrogen oxides • Gas mixtures containing oxygen higher than atmospheric concentrations (above 23%) | <ul style="list-style-type: none"> • Store oxidizers separately from flammable gas containers or combustible materials. minimum separation requirement from these materials is 20 ft. or a 5 ft. noncombustible barrier with a fire resistance rating of at least 30 minutes • Must be secured in upright position, bonded or chained against the wall • Clean equipment used for Oxygen and Nitrous Oxide with Oxygen compatible materials free from oils, greases and other contaminants • Fluorine shall be handled in specially passivated containers and associated equipment | <ul style="list-style-type: none"> • Flammable compressed gases • Toxic compressed gases | <ul style="list-style-type: none"> • Fire hazard • Explosion hazard • Use NIOSH approved gloves, eye protection and apron • Wear safety shoes |

Chemical Segregation

| Class of Chemicals | Common Chemical Examples | Additional Concerns and Storage Recommendations | Common Incompatible Chemical Types | Possible Reaction if Mixed/Health Concerns |
|--|---|--|--|---|
| <p>Toxic Compressed Gases</p>  | <ul style="list-style-type: none"> Carbon monoxide Hydrogen dioxide Arsenic Pentafluoride Boron tribromide Bromine Chlorine Fluorine Chloropicrin Cyanogen | <ul style="list-style-type: none"> Handle toxic compressed gases in a chemical fume hood Must be secured in upright position, bonded or chained against the wall Indoor storage or use of toxic compressed gases shall be provided with a gas cabinet, exhaust enclosure, or gas room | <ul style="list-style-type: none"> Flammable compressed gases Oxidizing compressed gases | <ul style="list-style-type: none"> Release of toxic gas Hydrogen sulfide is a colorless, flammable, extremely hazardous gas with a "rotten egg" smell. Prolonged exposure may cause nausea, tearing of the eyes, headaches or loss of sleep, or bronchial constriction in some asthma patients Possible fatigue, loss of appetite, headache, irritability, poor memory, dizziness and slight conjunctivitis Use NIOSH approved gloves, eye protection, face shield, & apron Wear safety shoes |
| <p>Carcinogens</p>  | <ul style="list-style-type: none"> Benzene Benzadine Methylene chloride Carbon tetrachloride Cadmium & compounds Arsenic & compounds Asbestos Alfatoxins Beryllium & compounds | <ul style="list-style-type: none"> Label all containers as "Cancer Suspect Agents" or the equivalent Store according to the hazardous nature of the chemical, using appropriate security when necessary | | <p>Use NIOSH approved gloves, eye protection, face shield, and apron</p> |
| <p>Teratogens</p>  | <ul style="list-style-type: none"> Tegretol Aminopterin Chlorobiphenyls Coumarins Tetracycline Tapazole Propylthioracil (PTU) | <ul style="list-style-type: none"> Label all containers as "Suspect Reproductive Hazard" or "Reproductive Effector" Store according to the hazardous nature of the chemical, using appropriate security when necessary | <ul style="list-style-type: none"> Aniline is incompatible with nitric acid and hydrogen peroxide | <ul style="list-style-type: none"> Use NIOSH approved gloves, eye protection, face shield, and apron |

Chemical Segregation

| Class of Chemicals | Common Chemical Examples | Additional Concerns and Storage Recommendations | Common Incompatible Chemical Types | Possible Reaction if Mixed/Health Concerns |
|---|---|---|---|---|
| <p>Flammable Aerosol Cans</p>  | <p>Pressurized Aerosol cans containing flammable liquid not limited to:</p> <ul style="list-style-type: none"> • Acetone • Thinner • Toluene • Petroleum Distillates • Butyl Cellusolve • Xylenes • Methanol | <p>Content under pressure:</p> <ul style="list-style-type: none"> • Store at room temperature; or store above 120°F • Do not use near heat, sparks and open flames • Always use secondary containers when storing with other chemicals | <ul style="list-style-type: none"> • See incompatibles for flammable liquids • Do not store acids, oxidizers, toxic and reactive chemicals • Use secondary containers with flat surfaces for stability | <ul style="list-style-type: none"> • Read instructions and usage as directed • Use NIOSH approve gloves or PPE. Rinse skin thoroughly with soap and water • Contact emergency services for severe skin impact or eye exposure |
| <p>Non-Flammable-Corrosive-Toxic Aerosol Cans</p>  | <p>Pressurized aerosol can NOT contain flammable liquid but not limited to corrosive or toxic carriers:</p> <ul style="list-style-type: none"> • Ammonia • Sodium hydroxide • Sodium hypochlorite • Amines | <p>Content under pressure:</p> <ul style="list-style-type: none"> • Store at room temperature • Do not use near heat, sparks and open flames • Always use secondary containers when storing with other chemicals | <ul style="list-style-type: none"> • See incompatibles for corrosive acid, base and toxic items above • Use a secondary container with flat surface for stability | <ul style="list-style-type: none"> • Read instructions and use as directed • Use NIOSH approve gloves or PPE. Rinse skin thoroughly with soap and water • Contact emergency services for severe skin impact or eye exposure |

Reference:

1. Adapted from Prudent Practices in the Laboratory: Handling and Disposal of Chemicals, National Research Council, 2011.
2. Boston University Environmental Health and Safety. (2011) Chemical Segregation and Storage.
3. The University of Texas Health Science Center at Texas. (2022). Chemical Segregation & Incompatibilities Guidelines. Chemical Hygiene Plan.
4. National Institute of Health. Division of Occupational Health and Safety.