



DOC #:	EHS-0023	Revision #:	1.7
DOC Type:	SOP	Implementation Date:	05/14/04
Page #:	1 of 26	Last Reviewed/Update Date:	01/08/19
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Chemical Storage

1. Purpose / Background

The purpose of this document is to provide information and procedures to assure chemicals are stored safely in the work area, and in compliance with local, state and federal regulations, standards, and guidelines. Safe chemical storage is an essential step in the safe management of hazardous chemicals. Proper storage involves assessing what you have, determining basic storage requirements, establishing optimum compatible groupings, dating items with a shelf-life, and making routine inspections of chemicals in storage, removing chemicals that are no longer needed, and correcting problems found.

2. Scope

This SOP pertains to storage of chemicals in MIT work areas such as laboratories and shops, and not to central chemical storage areas. However, the information in this SOP can be applied to central chemical storage facilities. This SOP does not cover storage of Compressed Gases. Storage of Compressed Gases is covered in the SOP EHS-0001 "Compressed Gases" (search for Compressed Gases on the Forms & SOPs page or Compressed Gas Cylinder Safety under the Chemical tab)

This SOP does broadly cover storage of flammable materials. However, detailed guidance regarding flammable material use and storage is provided in the SOP EHS-0020 "Flammable and Combustible Liquids" (search for Flammable and Combustible Liquids on the Forms & SOPs page)

This SOP broadly covers storage of peroxide forming materials. However, much more detail is provided in SOP EHS-0042 "Peroxide Forming Chemicals" (search for Peroxide Forming Chemicals on the Forms & SOPs page) and this document should be reviewed if you use and store such chemicals.

3. Prerequisites

- Knowledge of hazard terminology applicable to chemicals, including physical and health hazards. This hazard terminology is provided in section 10 below.
- Knowledge of all chemicals used and stored in the work area, to include the hazards of those chemicals. A list or inventory of chemicals in place with hazard information and maximum quantity information is useful for this purpose. A chemical list is required in

non-laboratory work areas and an inventory with quantity information is required for laboratory work areas.

Note: Laboratories can use the EHS Office supported chemical inventory system, the inventory system provides hazard information and storage information for chemicals. Details about the EHS Office chemical inventory system can be found at <http://ehs.mit.edu> under the Chemical tab or search for Chemical Inventory.

4. Procedures

4.1 General rules for safe chemical storage.

- Keep chemical stocks to a minimum and do not order or maintain excess quantities of any hazardous chemicals. Check current stocks before ordering to avoid duplication. Discard containers of chemicals that are no longer needed or that are no longer being used by members in the lab. If a chemical has not been used in 5 years and there is no planned use for the chemical, it should be properly disposed.
- When ordering new materials, make sure you have the capability to store those materials safely. Review an SDS before ordering for information on storage. Section 7 of safety data sheet contains general storage recommendations, and section 10 contains compatibility information.
- Provide enough space for chemical storage.
- Store chemicals in compatible containers that are in good condition with lids tightly closed.
- Make sure all containers are labeled with contents and are oriented so label is visible. For correct labeling of chemicals in laboratories, see the labeling guidelines in your DLC's Chemical Hygiene Plan. For correct labeling of chemicals for non-laboratory operations, see the guidance in the MIT Hazard Communication Program: (search for Hazard Communication on <http://ehs.mit.edu>)
- Date peroxide forming chemicals or chemicals that degrade over time when received and when opened. Also look at labels for expiration date and write that in bigger letters if it is not easily visible. For peroxide forming chemicals, review SOP EHS-0042, (search for Peroxide Forming Chemicals on the Forms & SOPs page), Peroxide-forming chemicals for more information and lists of such chemicals.
- For research chemicals generated and stored in the lab, label with content. Date and include researcher's initials on these chemicals.
- Store chemicals in groups based on compatibility, and NOT alphabetically.
 - Compatibility guidance is provided in Appendix A. You can also review the chemical's SDS "Stability/Reactivity" section (usually section 10) to determine incompatible materials.
 - For chemicals with Global Harmonization System (GHS) labels that contain pictograms, you can now readily determine a flammable material and an oxidizer, which should always be stored separately.

- Where possible, use separate cabinets for separate groups. Note: Most fume hoods have a flammable cabinet and a vented corrosive cabinet under them.
- If incompatible materials must be stored in the same cabinet, provide secondary containment, such as a gray plastic bin, for segregation.
- Store acids in vented acid cabinets to reduce corrosion.
 - Separate *oxidizing* acids (e.g. nitric acid) from *organic* acids (e.g. acetic acid) by use of secondary containers if there is insufficient space to store separately. Separate oxidizing acids from each other.
- Flammable liquid storage
 - Store bulk quantities in flammable storage cabinets
 - UL approved Flammable Storage Refrigerators are required for cold storage.
- Avoid floor storage of chemicals. If floor storage is needed, provide secondary containment. In no case should there be chemicals stored in the aisle or other major path of travel. (Note: Powder chemicals in their original shipping container do not need secondary containment.)
- Do not store hazardous liquids, especially corrosive liquids above eye level.
- On shelves, separate solids from liquids and store solids above liquids.
- Do not store items in the working space of fume hoods. Minimize chemical storage in fume hoods.
- Dispose of degraded, cracked, corroded, or leaking containers of hazardous chemicals as hazardous waste.
- Never stack chemical containers directly on each other.
- Do not store flammable, volatile toxic or corrosive chemicals in cold rooms.
- Do not store or use cryogenics in a cold room in amounts that can lead to an asphyxiating atmosphere. Contact EHS for guidance. Cold rooms have limited ventilation.
- For shared areas, establish a storage regime. Designate one person in charge of assuring proper maintenance of storage in the shared space.
- Maintain storage areas, cleaning up small spills immediately.

4.2 Common chemical storage problems seen during inspections.

- Nitric acid (an oxidizer) stored with organic acids such as acetic acid. Separate with secondary containers if there is not enough space to store these acids separately.
- Volatile toxic or flammable materials stored in the cold rooms. The ventilation is limited in these spaces. Cold rooms are not intended for chemical storage.
- Flammable materials stored in refrigerators not designed for flammable storage.
- Toxic or hazardous solids stored with liquids. Generally, most solids will be fairly safe in storage if kept dry.
- Undated or expired, out of date peroxide forming chemicals.
- Acids stored with bases.
- Corrosives (acids and bases) or other hazardous liquids stored above eye level.

- Storage of excessive amounts of chemicals in fume hoods not needed for experiments being conducted.
- Anhydrides not stored with secondary containment. They react with most things.
- Overcrowding and stacking of chemicals in storage areas.

4.3 Guidance for establishing and maintaining safe storage of chemicals in the work area.

In a laboratory where many chemicals are used, it may be difficult to assure optimum separation of all incompatible materials. However, steps can be taken to combine the majority of chemicals into compatible groupings, and then provide some extra containment for the more reactive chemicals.

Appendix A contains two schemes for grouping of chemicals for compatible storage, scheme one beginning at Part I of the Appendix, and scheme two beginning at Part IV of the Appendix. Storage scheme one is summarized with diagrams and a table after the descriptions of the different storage categories. There is a cross reference comparing the two storage schemes.

Please pay attention to comments and notes on tables in Appendix A and review the SDS carefully for highly reactive materials. Being aware of the more reactive chemicals in storage and taking some extra steps, as noted, can assure safety in storage. Some things may need an inert environment for safe storage and use. These materials should be identified, and appropriate facilities or equipment should be obtained to store these materials. Consult the EHS Office when ordering such materials.

- Step 1: review Appendix A. Review the chemical inventory, and the labels and SDS for the work area chemicals to determine and record the compatibility groups of the chemicals being used or stored, the types and sizes of containers belonging to that compatibility group, and the approximate total quantity of chemicals in that compatibility group.
 - Chemicals from some manufacturers or suppliers may have color coded labels and/or lids to help facilitate appropriate storage. Such color-coding is noted in Appendix A, but must be used with the label or SDS to assure the material is stored appropriately. Also, be aware that not all manufacturers or suppliers adhere to the color code scheme for the lids.
 - Pictograms, which will become more prevalent on container labels, can be used to easily group the flammable materials and the oxidizers. They can also be used to group corrosives, but these will need to be separated further.
 - In some cases, a specific chemical may belong to more than one compatibility group, e.g. highly toxic and flammable. The physical hazard of the chemical will usually take precedents over the health hazard for storage considerations.
- Step 2: Using the compatibility group information, assess the facilities and equipment in place for storage of chemicals. Refer to appendix A for basic storage considerations for chemicals in a given compatibility group. Obtain additional equipment and supplies, as needed, for storage of your chemicals. This may

include the need to install additional shelving and cabinetry, or the need to obtain secondary containers.

- Step 3: Label the different chemical storage areas with the compatibility group. Label the chemical containers with their storage location. Some people have used colored stick on dots for such labeling.
- Step 4: Assure chemicals are stored in their appropriate group, with the chemical labels readily visible. Those chemicals requiring receipt dates should be dated with this information.
- Step 5: Assure all personnel are informed of the storage procedures and compatibility groups established for the work area, and assure that the procedures are followed. This information can be provided during Lab Specific training required for each lab for new employees and annually for all employees.
- Step 6: Review chemical storage routinely, with a thorough inspection at least twice a year, to assure all materials are properly stored. Inspect to assure chemicals are in proper groups and containers and lids are in good condition. Remove and properly dispose expired chemicals, e.g. peroxide formers, or chemicals no longer being used.
- Step 7: On at least an annual basis, review chemicals in storage, and take action to recycle or properly dispose of materials no longer needed for operations and experiments in the work area. It is a good idea to update the chemical inventory at this time, if it is not maintained routinely.
- Step 8: When ordering a new chemical for the work area, consider its compatibility group and assure adequate facilities and space are available for storage of that chemical. Order the minimum quantity necessary for the application. Take action, as needed, to upgrade storage facilities to handle new chemicals being ordered. To prevent accumulation of unnecessary quantities of chemicals, it is suggested that labs order on a "just in time" basis. VWR offers "just-in-time" deliveries.

5. Responsibilities

5.1 EHS Office is responsible for:

- Providing General Chemical Hygiene training and MIT Overview HAZCOM training, to include information on chemical hazards.
- Maintaining up to date guidance pertaining to compatible storage of chemicals.
- Addressing questions or concerns pertaining to chemical storage.
- Assisting with inspections of chemical storage during Level II inspections or when requested.

5.2 PI's/Supervisors are responsible for:

- Assuring chemicals are stored safely in the laboratory/work areas they supervise using the guidance in this document or equivalent guidance.

- Assuring all personnel working in the area are informed of the chemical storage rules and practices established for the work area, and assuring they apply the information.
- Assuring periodic review of chemical storage in their work area, and assuring problems found are corrected.
- Assuring minimization of the amount of hazardous materials in storage in the work area, through an annual review of chemicals in storage and disposal or recycling of those chemicals no longer needed.

5.3 The DLC EHS Coordinator is responsible for:

- Assisting the PIs/Supervisors address chemical storage concerns.
- Consulting EHS with DLC questions or concerns regarding chemical storage.
- Periodically inspecting chemical storage and notifying PIs/Supervisors of problems found. Note: Chemical storage is evaluated as part of Level II inspections.

5.4 The EHS Representatives is responsible for:

- Assisting the PI/supervisor, as directed, with chemical storage in the work area. Specific duties may include identifying chemical storage needs and implementing good chemical storage practices in the work area.
- Periodically inspecting chemical storage areas, correcting readily correctable problems, and notifying the PI/Supervisor of problems found so that they can be corrected or prevented.
- Identifying opportunities for minimizing the hazardous materials stored in the work area.

5.5 Employees, students, or visitors working in a given laboratory or work area are responsible for:

- Knowing and following the chemical storage practices established in that laboratory/work area.

6. Training

Users of chemicals must receive training to understand the basic hazards of chemicals. For laboratory personnel, the training is called "General Chemical Hygiene Training". For non-laboratory personnel, this training is called "General HAZCOM Training". All personnel using hazardous chemicals must also receive workplace specific training. This training covers the hazards of chemicals specific to the workplace, and should include information on the chemical storage practices and rules established for the workplace. More details regarding chemical safety training can be found in the reference section below or in the DLC Chemical Hygiene Plans.

7. Monitoring Requirements

Work areas where hazardous chemicals are stored should be inspected during regular Level II inspections to assure the chemicals are being stored safely and in accordance with the rules established for the area. Note: Chemical storage is evaluated twice a year as part of Level II inspections conducted for the EHS Management System. However, it is a good practice for the PI and EHS representative to self-inspect for chemical storage in their area so that they are prepared for the Level II inspections. Once a year, this self-inspection should identify chemicals no longer needed for the area so action can be taken to recycle or properly dispose of the chemicals of concern.

8. Record Management

No records specific to chemical storage are required. However, it may be useful to keep records of the chemical storage rules and work practices established for a specific area, along with information regarding the hazard classes and compatibility groups of the chemicals stored in the area. The latter can be accomplished through a chemical list or inventory, as noted in prerequisites. In addition, as noted in prerequisites, the EHS Office provides a chemical inventory solution for maintaining a chemical inventory. The inventory system also provides hazard information for chemicals. Details about the EHS Office supported chemical inventory system can be found at <http://ehs.mit.edu> under the Chemical tab or search for Chemical Inventory.

There are various requirements, in general, for records with respect to hazardous chemical management. These record requirements are addressed in documents referenced in section 9 below.

9. References

9.1 Standards

The following references are available through the EHS Office:

- OSHA – 1910.1200 Hazard Communication
- OSHA – 1910.1450 Occupational Exposure to Hazardous Chemicals in Laboratories
- OSHA – 1910.1020 Access to Employee Exposure and Medical Records
- OSHA – 1910.106 Flammable and Combustible Liquids

9.2 Other SOP/ SOGs

Compressed Gases

Flammable and Combustible Liquids

Liquefied Petroleum Gases (SOP to be developed)

9.3 Supplementary Documents

MIT Environmental, Health and Safety Policy

MIT HAZCOM Program
DLC Chemical Hygiene Plans

9.4 Helpful Websites

OSHA Regulations: <http://www.osha.gov/>

10. Definitions

10.1 Chemical

Any element, chemical compound or mixture of elements and/or compounds.

10.2 Chemical name

The scientific designation of a chemical in accordance with the nomenclature systems developed by the International Union of Pure and Applied Chemistry (IUPAC) or the Chemical Abstracts Service (CAS) rules of nomenclature, or a name that will clearly identify the chemical for conducting a hazard evaluation.

10.3 Container

Any bag, barrel, bottle, box, can, cylinder, drum, reaction vessel, storage tank, or the like that contains a hazardous chemical. For purposes of this section, pipes or piping systems, and engines, fuel tanks, or other operating systems in a vehicle, are not considered containers.

10.4 Exposure or exposed

An employee is subjected in the course of employment to a chemical that is a physical or health hazard, and includes potential (e.g., accidental or possible) exposure. "Subjected" in terms of health hazards includes any route of entry (e.g., inhalation, ingestion, skin contact, or absorption).

10.5 Flammable liquid

A liquid having a flash point of not more than 93°C (199.4°F). Under GHS classification, there will be 4 categories of flammable liquids, with Category 1 being most flammable and Category 4 being the least flammable. Refer to a chemical's SDS for category of flammability.

10.6 Flashpoint

The minimum temperature at which a liquid gives off a vapor in sufficient concentration to ignite when tested using one of three methods given in OSHA 29 CFR 1910.1200 - Hazard Communication.

10.7 Hazardous chemical

Any chemical, which is a physical hazard or a health hazard.

10.8 Health hazard

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

10.9 Identity

Any chemical or common name, which is indicated on the safety data sheet (SDS) for the chemical. The identity used shall permit cross-references to be made among the required list of hazardous chemicals, the label and the SDS.

10.10 Label

Any written, printed or graphic material displayed on or affixed to containers of hazardous chemicals.

10.11 Safety data sheet (SDS)

A written or printed material concerning a hazardous chemical, which is prepared in accordance with requirements of OSHA 29 CFR 1910.1200 - Hazard Communication, paragraph g.

10.12 Mixture

Any combination of two or more chemicals if the combination is not, in whole or in part, the result of a chemical reaction.

10.13 Organic peroxide

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

10.14 Oxidizer

A chemical other than a blasting agent or explosive that initiates or promotes combustion in other materials, thereby causing fire either of itself or through the release of oxygen or other gases.

10.15 Physical hazard

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

10.16 Pyrophoric

A chemical will ignite spontaneously in air at a temperature of 130 degrees F (54.4 degrees C) or below.

10.17 Unstable (reactive)

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

10.18 Water-reactive

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

Appendix A: Chemical Compatibility Groups for Chemical Storage

As noted in the SOP, chemicals should be stored together based on their compatibility. There are a variety of schemes for compatible grouping of chemicals. Two schemes are presented in this document, with an additional option referenced. The information below is also summarized in the Chemical Storage Table Supplement to this SOP. Where possible, correlations between the two systems are noted in the information in this Appendix. You can select an option that works best for the types of chemicals you have in your laboratory. However, if you choose an option other than those provided, we recommend you review it with EHS before proceeding. Please pay attention to special notes in the groupings. It is difficult to find a storage scheme that assures all materials in a group are completely compatible, so additional separation with secondary containers is specified when needed.

Generally, the guidelines refer to liquid chemicals, with some exception for air reactives and water reactives. In most cases, solids in the laboratory that are kept dry can be stored on a shelf. It is recommended that liquids stored on shelves be kept separate from and below solids stored on shelves.

Resources for determining chemical compatibility are below. They are designed primarily for use when mixing two chemicals, but can also help to determine appropriate storage for a chemical.

(You can download this worksheet program).

- University of Washington - Chemical Compatibility Chart:
<http://www.ehs.washington.edu/fsosurveys/chemcompat.shtm>
- PennState – Chemical Safety – Resources: Chemical Compatibility Chart:
<http://ehs.psu.edu/chemical-safety/resources>

Another good source of information for reactivity and incompatibility is the WISER (Wireless Information System for Emergency Responders) created by NIH. You can download the application on your computer.

<https://wiser.nlm.nih.gov/>

In order to organize chemicals into compatible storage groups, it is important to understand the physical hazards and health hazard the chemical presents. Review the chemicals in the work area and determine which compatibility group the chemical belongs in. If more than one hazard applies, priority should be given to the physical hazard of the material for storage in most cases. For example, if a substance is toxic and flammable, it should be stored as a flammable material. If something is toxic and a base, it should be stored as a base. If more than one physical hazard applies, use the lower number storage group. For example, if something is an oxidizer and an acid, it should be stored as an oxidizing acid.

Appendix A: Chemical Compatibility Groups for Chemical Storage

A list of the compatibility groups is provided in Part I. below. Examples of chemicals that fit in a group and guidance regarding proper storage of chemicals in that group is provided in Part II below.

Note: There may be additional consideration for storage of some chemicals beyond compatibility group. For example, oxidizers represent a highly reactive group of chemicals, and in many cases, they should be isolated from each other within the group by use of secondary containers.

Storage Scheme One:

This is the initial scheme proposed for MIT.

There is table of this scheme at the end of this section and it can be printed separately.

Part I. Compatibility group

Group	Hazard	Color code
Group I (L)	Flammable Liquids	Red
Group II (L)	Poisons- volatile	Blue
Group III (E)	Acids - Oxidizing	Yellow (for reactive)
Group IV (D)	Organic Acids Mineral Acids	White for corrosive and red for flammable (Organic acids are often flammable or combustible).
Group V (C)	Bases	White (corrosive)
Group VI (E)	Oxidizer – Liquid	Yellow (reactive)
Group VII (No equivalent)	Poisons – Non-volatile	Blue (poison)
Group VIII (B, X, K)	Reactives	Yellow
Group IX (G)	Solids	Gray

Note: Letters denote the Correlating Storage Scheme Two group.

Appendix A: Chemical Compatibility Groups for Chemical Storage

Part II. Storage Group Information

Group I: Flammable and Combustible Liquids	
Properties	Liquids with flashpoints < 199 F
Examples	All alcohols, acetone, acetaldehyde, acetonitrile, amyl acetate, benzene, cyclohexane, dimethyldichlorosilane, dioxane, ether, ethyl acetate, histoclad, hexane, hydrazine, methyl butane, picolene, piperidine, propanol, pyridine, scintillation liquids, all silanes, tetrahydrofuran, toluene, triethylamine, xylene.
Primary Storage Concern	To protect from ignition
Recommended Facilities/ Measures	1. Flammable cabinet 2. Flammable storage refrigerator for containers less than 1 liter of highly flammable materials (OSHA GHS Category 1 or NFPA Class 1A) with a flashpoint at 73 °F or lower and a boiling point below 100 °F.
Compatible Storage Groups	Volatile poisons may be in the same compartment of the flammable cabinet as flammables if bases are not present.
Special Note	All containers of flammable liquids (flashpoint <199 F) should be returned to the flammable cabinet or explosion-safe/proof refrigerator/freezer immediately after use. Do not store flammables in cold rooms, which have limited or no ventilation, and are not explosion proof. Peroxide formers must be stored in the flammable cabinets and must be dated on receipt and regularly inventoried to track their age. See SOP. Organic acids could be grouped in this hazard group because they have flashpoints below 140, but because the flammable cabinets are not always vented, they are grouped based on their corrosive properties in this scheme.
Group II: Volatile Poisons	
Properties	Includes poisons, toxics and known and suspected carcinogens with strong odor or evaporation rate greater than 1 (butyl acetate = 1).
Examples	Carbon tetrachloride, chloroform, dimethylformamide, dimethyl sulfate, formamide, formaldehyde, halothane, mercaptoethanol, methylene chloride, phenol
Primary Storage Concern	To prevent inhalation exposures
Recommended Facilities/ Measures	1. Ventilated Flammable cabinet 2. Refrigerator: for containers less than 1 liter

Appendix A: Chemical Compatibility Groups for Chemical Storage

Compatible Storage Groups	<p>Volatile poisons may be in the same compartment of the flammable cabinet as flammables if bases are not present. It should be noted, though, that many flammable cabinets are not vented, so if there are a lot of volatile toxics, venting of the cabinet may need to be added.</p>
Group III: Oxidizing acids	
Properties	All oxidizing acids are highly reactive with most substances and each other
Examples	Nitric, sulfuric, Perchloric, and chromic acids
Primary Storage Concern	Preventing contact and reaction with each other and other substances, especially organic chemicals, and corrosive action on surfaces
Recommended Facilities/ Measures	Ventilated corrosion resistant safety cabinet Each oxidizing acid must be double contained, i.e., the primary container must be kept inside canister, tray or tub.
Compatible Storage Groups	<p>Oxidizing acids must be double contained with each type of acid in its own second container, and should be segregated in their own compartment in a safety cabinet.</p> <p>When quantities are small (e.g., 1 or 2 bottles) they do not warrant a separate compartment. Small quantities, if double-contained, may be stored with Group 4 Organic and Mineral Acids if the organic acids are also double contained to separate them from the oxidizing acids.</p>
Group IV: Organic and Mineral Acids	
Examples	Acetic, butyric, formic, glacial acetic, hydrochloric, isobutyric, mercaptopropionic, phosphoric, propionic, trifluoroacetic acids
Primary Storage Concern	To prevent contact and reaction with bases and oxidizing acids and corrosive action on surfaces
Recommended Facilities/ Measures	Ventilated corrosion resistant safety cabinet
Compatible Storage Groups	Small amount of double-contained oxidizing acids can be stored in the same compartment with organic acids if the oxidizing acids are stored on the bottom shelf and the organic acids are double contained.
Special Note	Exceptions: acetic anhydride and trichloroacetic anhydride are corrosive. These acids are very reactive with other acids and should not be stored in this group. It is better to store these with organic compounds as in Group 7 Non-volatile Liquid Poisons.

Appendix A: Chemical Compatibility Groups for Chemical Storage

Group V: Liquid Inorganic Bases	
Examples	Sodium hydroxide, ammonium hydroxide, calcium hydroxide, potassium hydroxide, aqueous ammonia
Primary Storage Concern	Preventing contact and reaction with acids
Recommended Facilities/Measures	1. Corrosion resistant safety cabinet 2. In tubs or trays in normal cabinet
Compatible Storage Groups	Liquid bases may be stored with flammables in the flammable cabinet if volatile poisons are not also stored there.
Group VI: Oxidizing Liquids	
Properties	Oxidizing liquids react with everything potentially causing explosions or corrosion of surfaces.
Examples	Ammonium persulfate, hydrogen peroxide (if greater than or equal to 30%),
Primary Storage Concern	To isolate from other materials
Recommended Facilities/Measures	1. Total quantities exceeding 3 liters should be kept in a cabinet housing no other chemicals. 2. Smaller quantities must be double contained if kept near other chemicals, e.g., in a refrigerator.
Special Note	Oxidizers should not be stored directly on wooden shelves or on paper shelf liners. Spills may react and ignite spontaneously.
Group VII: Non-Volatile Liquid Poisons	
Properties	Includes highly toxic (LD50 oral rat < 50 mg/kg) and toxic chemicals (LD50 oral rat < 500 mg/kg), known carcinogens, suspected carcinogens and mutagens
Examples	Acrylamide solutions; diethylpyrocarbonate; diisopropyl fluorophosphate; uncured epoxy resins; ethidium bromide; triethanolamine
Primary Storage Concern	To prevent contact and reaction with other substances
Recommended Facilities/Measures	Cabinet or refrigerator (i.e., must be enclosed) Do not store on open shelves in the lab or cold room. Liquid poisons in containers larger than 1 liter must be stored below bench level on shelves closest to the floor. Smaller containers of liquid poison can be stored above bench level only if behind sliding (non-swinging) doors.
Compatible Storage Groups	Non-hazardous liquids (e.g., buffer solutions).

Appendix A: Chemical Compatibility Groups for Chemical Storage

Special Note	Exceptions: Anhydrides, e.g., acetic and trichloroacetic, are organic acids, however it is better to store these acids with this group than with Group 4 Organic Acids, since they are highly reactive with other organic or mineral acids.
Group VIII: Reactives, Metal Hydrides, and Pyrophorics	
Properties	Most metal hydrides react violently with water; some ignite spontaneously in air (pyrophoric).
Examples	Examples of metal hydrides are sodium borohydride, calcium hydride, and lithium aluminum hydride. Other pyrophorics are boron, diborane, dichloroborane, 2-Furaldehyde, diethyl aluminum chloride, lithium, white or yellow phosphorus and trimethyl aluminum. Other water reactives include aluminum chloride-anhydrous, calcium carbide, acetyl chloride, chlorosulfonic acid, sodium, potassium, phosphorous pentachloride calcium, aluminum tribromide, calcium oxide, and acid anhydrides.
Primary Storage Concern	To prevent contact and reaction with liquids and, in some cases, air.
Recommended Facilities/ Measures	<ol style="list-style-type: none"> 1. Secure, waterproof double-containment according to label instructions 2. Isolation from other storage groups of liquid chemicals
Compatible Storage Groups	If securely double contained to prevent contact with water and/or air, metal hydrides may be stored in the same area as Group 9 Dry Solids.
Group IX: Dry Solids	
Properties	Includes all powders, hazardous and non-hazardous
Examples	Benzidine, cyanogen bromide, ethylmaleimide, oxalic acid, potassium cyanide, sodium cyanide
Primary Storage Concern	To prevent contact and potential reaction with liquids
Recommended Facilities/ Measures	<ol style="list-style-type: none"> 1. Cabinets are recommended, but if not available, open shelves are acceptable. 2. Store above liquids 3. Warning labels on highly toxic powders should be inspected and highlighted or amended if they do not cause the containers to stand out against less toxic substances in this group. 4. It is recommended that the most hazardous substances in this group be segregated. 5. It is particularly important to keep liquid poisons below cyanide-or sulfide-containing poisons (solids). A spill of aqueous liquid onto

Appendix A: Chemical Compatibility Groups for Chemical Storage

	cyanide - or sulfide - containing poisons would cause a reaction that would release poisonous gas.
Compatible Storage Groups	Metal hydrides, if properly double contained may be stored in the same area.
Special Note	Exceptions: Solid picric or picric sulfonic acid can be stored with this group, but should be checked regularly for dryness. When completely dry, picric acid is explosive and may detonate upon shock or friction. Picric acid in contact with some metals may form explosive metal picrates. Use non-metal caps.

Note regarding Compressed Gases -Segregate according to hazard class. Acutely toxic and toxic gases should be stored in gas cabinets or fume hoods. For detailed storage guidance see the SOP "Compressed Gases"

Note regarding Controlled Substances - Narcotics and other controlled substances should be stored in a secure, locked location such as a drawer or safe. For details on controlled substance storage, go to:

Note regarding Securing Other Highly Hazardous Materials – Consideration should be given to the security of materials in your lab. Select Toxins, a group of regulated highly toxic biotoxins must be stored securely. Lock boxes are available from EHS. Other highly toxic compounds should be stored securely whenever feasible.

Contact EHS at 617-452-3477 for more information regarding chemical storage.

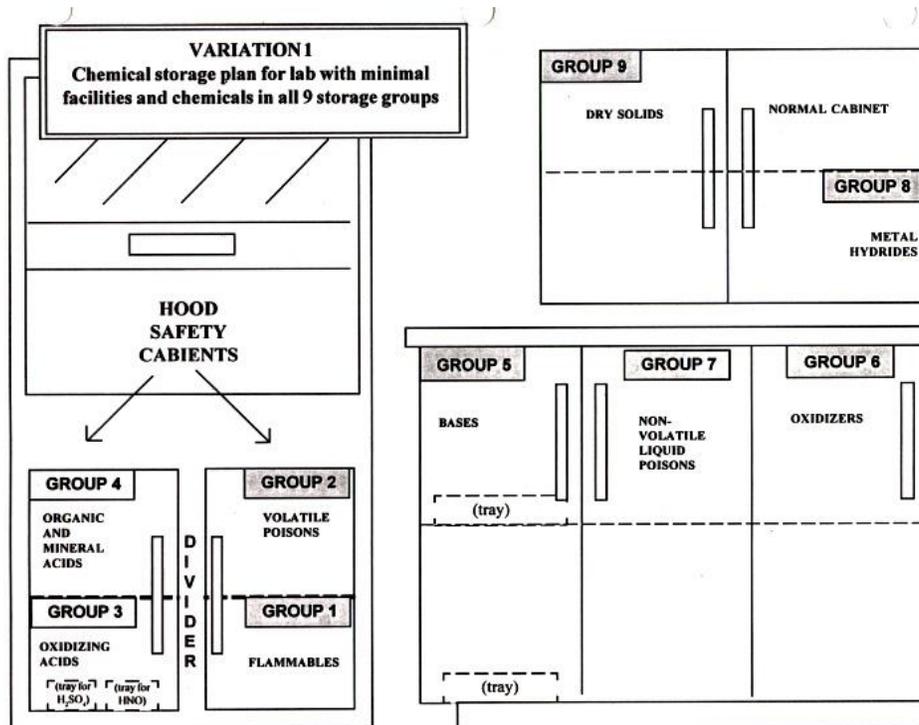
Part III: Storage Plan Examples for Different Lab Facilities

On the following pages are illustrations of possible chemical storage arrangements for two types of lab facilities. They are provided merely as examples of arrangements, which satisfy the recommendations of the chemical storage plan. They are not intended to restrict storage designers to the particular arrangements and facilities depicted.

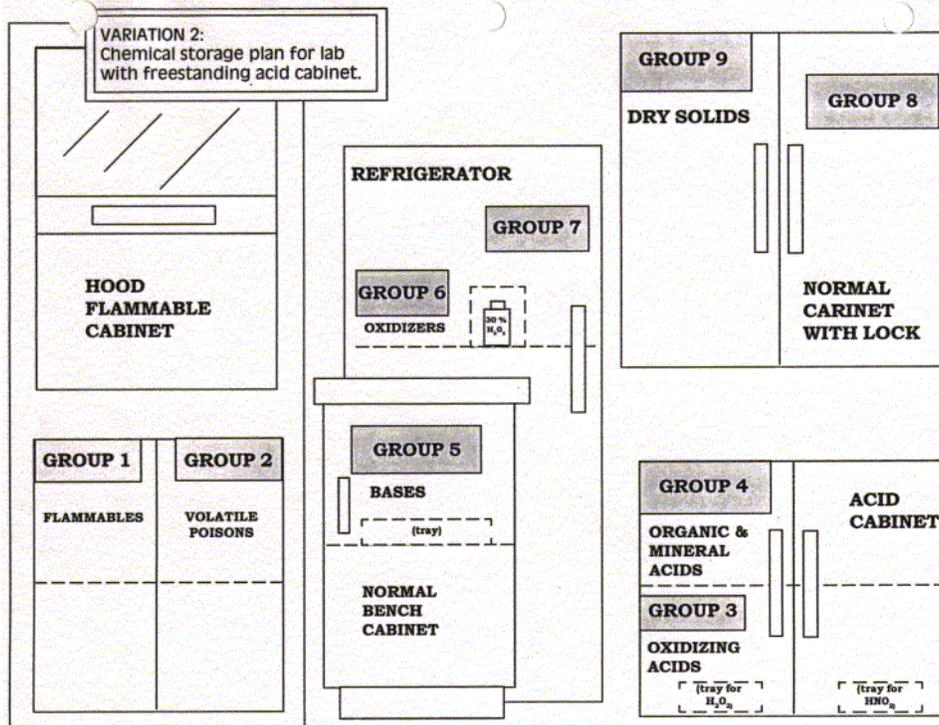
Variation 1:

Chemical storage plan for lab with minimal facilities and chemicals in all 9 storage groups.

Appendix A: Chemical Compatibility Groups for Chemical Storage



Variation 2:
Chemical storage plan for lab with freestanding acid cabinet.



Appendix A: Chemical Compatibility Groups for Chemical Storage

Chemical Storage Table Supplement for Chemical Storage Scheme One SOG (7-11)				
Flammable Toxic Reactive Corrosive				
Group	Properties	Important Notes	Storage	Examples
<p style="color: red;">Group 1</p> <p style="color: red;">Flammables and Combustibles</p> <p style="color: red;">AKA: organics, solvents</p>	<p style="color: red;">Flammable liquids have a flashpoint (FP) below 100°F (38°C).</p> <p style="color: red;">Combustible liquids have a flashpoint above 100°F and below 140°F</p> <p style="color: red;">Flashpoint is the lowest temperature at which a liquid gives off enough vapor to ignite.</p>	<p style="color: red;">The SDS provides the flashpoint for flammable and combustible liquids.</p> <p style="color: red;">Ignition sources include spark from electrical outlet, vacuum pumps, and static electricity.</p>	<p style="color: red;">FP ≤ 199°F (93 °C) store in a metal flammable cabinet that is completely enclosed. If vented, the vent must have a flash arrestor.</p> <p style="color: red;">NO cardboard shipping boxes in the cabinet.</p> <p style="color: red;">Never store in cold rooms or refrigerators (unless the refrigerator is explosion-proof).</p> <p style="color: red;">Do not store with oxidizers or inorganic acids.</p>	<p style="color: red;"><u>All alcohols</u>: butanol, ethanol, methanol, isopropanol, etc.</p> <p style="color: red;">Acetone, acetaldehyde, acetonitrile, amyl acetate, benzene, cyclohexane, dimethyldichlorosilane, dioxane, ether, ethyl acetate, hexane, hydrazine, methyl butane, picolene, pyridine, all silanes, tetrahydrofuran, toluene, triethylamine, xylene, etc.</p> <p style="color: red;"><u>Combustibles</u>: dimethylformamide, formaldehyde</p>
<p style="color: red;">Peroxide-formers</p> <p style="color: red;">Generally, Group I</p>	<p style="color: red;">Highly flammable. May form low-power explosives that are very sensitive to shock, sparks, light, strong oxidizing and reducing agents, friction, and high temperatures.</p>	<p style="color: red;">Read Peroxide-Forming Chemicals SOP</p> <p style="color: red;">Distillation, evaporation, or other concentration can present a high risk of explosion.</p> <p style="color: red;">Test for peroxide formation monthly.</p>	<p style="color: red;">Store with flammables.</p> <p style="color: red;">Date when received and when opened.</p> <p style="color: red;">Dispose of as hazardous waste after 12 months.</p>	<p style="color: red;">Ether (diethyl and isopropyl), tetrahydrofuran, acetaldehyde, etc.</p>

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Flammable Toxic Reactive Corrosive				
Group	Properties	Important Notes	Storage	Examples
<p>Group II (volatile) and VII (non-volatile) Toxics AKA: poisons, organics, halogenated solvents, carcinogens, mutagens, reproductive toxins</p>	<p>Chronic exposure is a health hazard. Avoid inhalation, skin contact.</p> <p>Many toxic solvents are highly volatile.</p> <p>Non-flammable (some are combustible).</p>	<p>Commonly mistaken for a flammable liquid.</p>	<p>OK to store with flammables in vented flammable cabinet.</p> <p>Alternative: Any enclosed cabinet or shelf to protect from accidental breakage.</p> <p>Store containers larger than 1 liter below bench level.</p> <p>Do not store with bases.</p>	<p><u>Volatile toxics:</u> carbon tetrachloride, chloroform, dimethyl sulfate, halothane, mercaptoethanol, methylene chloride (dichlormethane), phenol</p> <p><u>Non-volatile toxics:</u> acrylamide solutions, ethidium bromide, triethanolamine</p>
<p>Group III (oxidizing acids)</p>	<p>Oxidizing acids are highly reactive, and may react with each other. Corrosive, burns skin and eyes.</p>	<p>Concentrated (> 70%) perchloric acid reacts with wood and paper and may ignite. Never store concentrated perchloric acid directly on wood shelves without a plastic tub. Also, see Group IV.</p>	<p>Store in vented cabinets. Oxidizing acids should be separated from each other by use of a plastic tub. Oxidizing acids can be stored with mineral acids but not organic acids unless appropriately isolated and amounts are small</p>	<p><u>Oxidizing inorganic acids:</u> nitric, sulfuric, perchloric, chromic</p>

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Group	Properties	Important Notes	Storage	Examples
Group IV Mineral Acids and Organic Acids	<p>Corrosive, burns skin and eyes.</p> <p>Organic acids are combustible (FP >100°F<140°F)</p>	<p>Acid mist escapes from closed bottles and builds up inside un-vented cabinets causing corrosion of labels, metal cabinets, etc.</p>	<p>Store in the vented cabinet under fume hood or in a vented stand alone cabinet.</p> <p>Do not store with bases.</p> <p>Store below eye level.</p> <p>It is a good idea to keep hydrofluoric acid in a separate tub or tray to avoid contamination of surfaces.</p>	<p><u>Mineral acids:</u> hydrochloric, phosphoric, hydrofluoric</p> <p><u>Organic acids:</u> acetic, acrylic, butyric, formic, glacial acetic, isobutyric, mercaptopropionic, trifluoroacetic, etc.</p>
Group V Liquid Inorganic Bases AKA: alkaline	<p>Corrosive burns skin and eyes.</p>	<p>Avoid contact with acids and volatile toxics.</p>	<p>Store in a separate cabinet.</p> <p>Alternative: store with other chemicals and keep in a separate tub or tray.</p> <p>Can be stored with flammables if no volatile toxic (halogenated organics) are present.</p> <p>Store below eye level.</p>	<p>Sodium hydroxide, ammonium hydroxide, calcium hydroxide, potassium hydroxide, aqueous ammonia</p>

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<p>Group VI Oxidizing Liquids</p> <p>(Excluding Oxidizing acids)</p> <p>AKA: reactives</p>	<p>Provides oxygen that feeds fires and makes fires very difficult to extinguish.</p> <p>Oxidizing liquids react with many things potentially causing explosions or corrosion of surfaces.</p>	<p>The oxidizer symbol (a burning O) may be mistaken for a flammable symbol (a flame). Oxidizers are considered ignitable for hazardous waste management purposes.</p>	<p>Store on a separate shelf. Do not store directly on wood shelf or paper.</p> <p>If stored near other chemicals, including other oxidizers keep in a separate tub or tray.</p> <p>Do not store with flammables.</p>	<p>Ammonium persulfate, hydrogen peroxide \geq 30%</p>
<p>Group VIII Pyrophorics and Water Reactives</p>	<p>Ignite spontaneously in air. Water reactives can react with moisture in the air to produce a flammable gas.</p> <p>Metal hydrides react violently with water, some ignite spontaneously in air.</p>	<p>Read Pyrophoric and Water Reactives SOP</p>	<p>Waterproof double containment (the shipping container may be an appropriate second container).</p> <p>Isolate from other chemicals. OK to store with dry chemicals.</p> <p>Do not store with liquid chemicals (oxidizers, flammables, acids, bases, toxics etc.)</p> <p>May need an inert environment such as a nitrogen filled desicator jar.</p>	<p><u>Metal hydrides:</u> sodium borohydride, calcium hydride, lithium aluminum hydride, etc.</p> <p><u>Pyrophorics:</u> borane, diborane, dichloroborane, lithium, phosphorous, 2-furaldehyde, diethyl aluminum chloride, trimethyl aluminum, etc.</p> <p><u>Water Reactives:</u> aluminum chloride anhydrous, calcium carbide, acetyl chloride, chlorosulonic acid, sodium, potassium, phosphorous</p>

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Group	Properties	Important Notes	Storage	Examples
				pentachloride calcium, aluminum tribromide, calcium oxide, acid anhydrides etc.
Group IX Dry Solids	Varies. They are dry, but when wet, may have different properties, depending on the material.	Keep Dry. Indicate where the more toxic materials are located. (See SOP)	Cabinets are suggested, but shelves are O.K. Store above liquids and separate from liquids.	<u>Benzidine, cyanogens, bromide, oxalic acid, potassium hydroxide.</u>
Chemicals with no great storage options, e.g. anhydrides	These materials react with many things.	Keep isolated in some way by using secondary containment. Minimize quantities on hand.	Will depend on specific chemical. Call EHS for guidance.	Acetic anhydride, trichloro acetic anhydride

Basic Rules	Common Problems
<ul style="list-style-type: none"> ▪ Store in compatible groups. Consult above referenced SOP, manufacturer's recommendations and SDS. (To obtain SDS, Google search: chemical name SDS, or type SDS on MIT Home page search to see link to MIT SDS link page.) ▪ Minimize chemicals purchased, especially flammables and reactives. ▪ Label storage areas, and label all chemicals being stored. ▪ Store hazardous liquids below eye level. ▪ Make sure chemical containers are in good condition and are compatible with contents. ▪ Lids should be tightly closed. ▪ Secondary containment for floor storage. ▪ Do not store solids with liquids ▪ Do not store items in working space of fume hoods. ▪ Do not store flammable, volatile toxic, or corrosive materials in cold rooms 	<ul style="list-style-type: none"> ▪ Nitric acid (an oxidizer) stored with organic acids such as acetic acid. Separate with secondary containers if there is not enough space to store these acids separately. ▪ Volatile toxic or flammable materials stored in the cold rooms. The ventilation is limited in these spaces. Cold rooms are not intended for chemical storage. ▪ Flammable materials stored in refrigerators not designed for flammable storage. ▪ Toxic or hazardous solids stored with liquids. Generally, most solids will be fairly safe in storage if kept dry. ▪ Undated or expired, out of date peroxide forming chemicals. ▪ Acids stored with bases.

Appendix A: Chemical Compatibility Groups for Chemical Storage

<ul style="list-style-type: none">▪ Annually discard unused, unwanted, and expired chemical	<ul style="list-style-type: none">▪ Corrosives (acids and bases) or other hazardous liquids stored above eye level.▪ Storage of excessive amounts of chemicals in fume hoods not needed for experiments being conducted.▪ Anhydrides not stored with secondary containment. They react with most things.▪ Overcrowding and stacking of chemicals in storage areas.
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Note: The compatibility groups are guidelines. There are other options for chemical storage. If you have a specific problem or question regarding chemical storage, please contact EHS at 2-3477 or email environment@mit.edu, and let them know you have a chemical storage question.

Appendix A: Chemical Compatibility Groups for Chemical Storage

Part IV. Storage Scheme Two

Group	Group	Scheme One Correlation
A	Compatible Organic Bases	None
B	Compatible Pyrophoric and Water Reactive Materials	VIII
C	Compatible Inorganic bases	V
D	Compatible organic acids	IV (in part)
E	Compatible Oxidizers	III and VI
F	Compatible Inorganic Acids not including Oxidizers	IV
G	Not Intrinsically Reactive or Flammable or Combustible	II, VII, and IX
J	Poison Compressed Gases	None
K	Compatible Explosive or other highly Unstable Materials	VIII
L	Non-Reactive Flammables and Combustibles, including solvents	I, II
X	Incompatible with all other groups	VIII

Table below taken from Stanford University at

<http://www.stanford.edu/dept/EHS/prod/researchlab/lab/chemstorage.pdf>

Appendix A: Chemical Compatibility Groups for Chemical Storage

Stanford University Compatible Storage Group Classification System
should be used in conjunction with specific storage conditions taken from the manufacturer's label and MSDS.

STORAGE GROUPS

Store chemicals in separate secondary containment and cabinets
Find Storage Group information in Chemtracker:
<https://chemtracker.stanford.edu/chemsafety>

A	Compatible Organic Bases
B	Compatible Pyrophoric & Water Reactive Materials
C	Compatible Inorganic Bases
D	Compatible Organic Acids
E	Compatible Oxidizers including Peroxides
F	Compatible Inorganic Acids not including Oxidizers or Combustibles
G	Not Intrinsically Reactive or Flammable or Combustible
J*	Poison Compressed Gases
K*	Compatible Explosive or other highly Unstable Materials
L	Non-Reactive Flammables and Combustibles, including solvents
X*	Incompatible with ALL other storage groups

*Storage Groups J, K and X: Contact EH&S @ 3-0448
For specific storage - consult manufacturer's MSDS

If space does not allow Storage Groups to be kept in separate cabinets the following scheme can be used with extra care taken to provide stable, uncrowded, and carefully monitored conditions.

SHELF 1

SHELF 2

Storage Group X must be segregated from all other chemicals.

Storage Group B is not compatible with any other storage group.

Last updated: 05/01/05

*For questions regarding J, K, or X at MIT, contact MIT EHS Office at 2-3477.