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, in compliance with local, state, and federal regulations, standards, and guidelines. Safe chemical storage can set the stage for a better understanding of the chemicals hazards in the work area, knowledge required by the OSHA Chemical Hygiene Plan Standard and OSHA Hazard Communication Standard. In addition, safe storage will reduce the likelihood of (1) accidental misuse of chemicals, (2) accidents associated with chemical handling, and (3) serious incidents associated with leaks of chemicals in their storage location. Finally, safe storage of chemicals will improve overall management of chemicals by reducing the likelihood of ordering chemicals already in place and by reducing the presence of unknown chemicals and this will lead ultimately to reducing the amount and cost of hazardous chemical waste.

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 “Compressed Gases”. This SOP does broadly cover storage of flammable materials. However, detailed guidance regarding flammable material use and storage is provided in the SOP “Flammable Liquids”.

3. Prerequisites

- Knowledge of hazard terminology applicable to chemicals, including physical hazards 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 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 strongly encouraged for laboratory work areas. Laboratories now have access to ChemTracker, a powerful inventory system that provides hazard information and storage information for chemicals. Details on ChemTracker can be found at http://ehs.mit.edu/site/content/chemical-inventory.

4. Procedures

4.1 General rules for safe chemical storage.

- Keep chemical inventory to a minimum and do not maintain excess quantities of any hazardous chemicals.
- When ordering new materials, make sure you have the capability of storing those materials safely. Review an MSDS before ordering for information on storage.
- Separate all chemicals according to compatibility groups based on hazard class and storage scheme selected (See Appendix A) and store them in labeled storage areas or cabinets. Provide secondary containment, when necessary, for separation and safe storage of materials.
- Make sure chemical containers are in good condition and are compatible with contents. Keep chemical lids securely in place on stored materials. Dispose of degraded, spilled or leaking containers of hazardous chemicals as hazardous waste.
• Make sure all chemicals in storage are labeled. Store chemicals so that labels are readily 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.
• Date peroxide formers and other chemicals that degrade over time when received and when opened. Review the label or product information for recommended shelf life, and put disposal date on the container as well. Check these materials routinely to assure they are used or disposed of by their disposal date.
• Avoid storing hazardous chemicals on countertops or in fume hoods except for those chemicals needed for immediate use.
• Store hazardous materials, especially hazardous liquids in glass containers, below eye level.
• Avoid storing excess quantities of flammable materials and use a flammable storage cabinet when necessary. (See flammable material storage guidelines.)
• Do not keep flammable materials in domestic household refrigerators. Use a flammable storage refrigerator. All refrigerators must be clearly labeled regarding whether or not they are safe for storage of flammables.
• Do not store flammable, volatile toxic or corrosive chemicals in cold rooms.
• Do not store or use cryogens in a cold room in amounts that can lead to an asphyxiating atmosphere. Contact EHS for guidance. Cold rooms have limited ventilation.
• Store acids in vented storage cabinets when possible. Separate oxidizing acids such as nitric acid from organic acids such as acetic or formic acid.
• On shelves, separate solids from liquids and store solids above liquids.
• For shared areas, all users should adhere to storage regime established for the shared area. Procedures in the next section can be used for establishing storage in shared areas. All PIs/Supervisors with personnel using the shared space are responsible for safe storage of chemicals in that space. It may be useful to designate one person in charge of assuring proper maintenance of storage in the space.
• When possible, avoid storing chemicals on the floor. If the floor is used for storage, except as noted below, all chemicals stored on the floor must be in secondary containers similar to those used for Satellite accumulation areas. This is to help protect the chemical containers from damage. Powder chemicals in their original shipping container do not need secondary containment. In no case should there be chemicals stored in the aisle or other major path of travel.

4.2 Guidance for establishing and maintaining safe storage of chemicals in the work area.
• Determine and record the compatibility groups of the chemicals being used or stored in the work area, the types and sizes of containers belonging to that compatibility group, and the approximate total quantity of chemicals in that compatibility group. The determination of compatibility groups can be made by using the label and MSDS, and Appendix A and selecting either Storage Scheme One beginning at Part I, or Storage Scheme Two beginning at Part IV. Storage Scheme Two corresponds to the ChemTracker chemical inventory system. 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 MSDS to assure the material is stored appropriately. Also, be aware that not all manufacturers or suppliers adhere to the color code scheme. Note: 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 precedence over the health hazard for storage considerations.
• 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.

• 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.

• Assure chemicals are stored in their appropriate group, with the chemical labels readily visible.

• 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.

• Review chemical storage routinely, with a thorough inspection at least twice a year, to assure all materials are properly stored. Note: Chemical storage is evaluated as part of Level II Inspections done under the EHS Management System. However, it is a good idea for organizations working with chemicals to inspect their areas to assure they are storing chemicals properly and to prepare for these Level II inspections.

• On an annual basis, review chemicals in storage, and take action to recycle or properly dispose of materials no longer needed for operations in the work area. It is a good idea to update the chemical inventory at this time, if it is not maintained routinely.

• When ordering a new chemical for the work area, consider its compatibility group and assure adequate facilities are available for storage of that chemical. Order the minimum quantity necessary for the application. Take action, as needed, to upgrade storage facilities in order 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 being 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, as noted in prerequisites. Also, as noted in prerequisites, there is available at MIT a new tool for maintaining a chemical inventory, ChemTracker, an inventory system that provides hazard information and storage information for chemicals. Details on ChemTracker can be found at [http://ehs.mit.edu/site/content/chemical-inventory](http://ehs.mit.edu/site/content/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 means any element, chemical compound or mixture of elements and/or compounds.

10.2. Chemical name means 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 which will clearly identify the chemical for the purpose of conducting a hazard evaluation.

10.3. Combustible liquid means any liquid having a flashpoint at or above 100 degrees F (37.8 degrees C), but below 200 degrees F (93.3 degrees C), except any mixture having components with flashpoints of 200 degrees F (93.3 degrees C), or higher, the total volume of which make up 99 percent or more of the total volume of the mixture.

10.4. Container means 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 to be containers.

10.5. Exposure or exposed means that 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).

10.6. Flammable, as defined by OSHA, means a chemical that falls into one of the following categories:

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

10.6.2. Gas, flammable means: (A) A gas that, at ambient temperature and pressure forms a flammable mixture with air at a concentration of thirteen (13) percent by volume or less; or (B) a
gas that, at ambient temperature and pressure, forms a range of flammable mixtures with air wider than twelve (12) percent by volume, regardless of the lower limit;

10.6.3. **Liquid**, flammable means any liquid having a flashpoint below 100 degrees F (37.8 degrees C) except any mixture having components with flashpoints of 100 degrees F (37.8 degrees C) or higher, the total of which make up 99 percent or more of the total volume of the mixture.

10.7. **Flashpoint** means 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.

10.8. **Foreseeable emergency** means any potential occurrence such as, but not limited to, equipment failure, rupture of containers, or failure of control equipment which could result in an uncontrolled release of a hazardous chemical into the workplace.

10.9. **Hazardous chemical** means any chemical, which is a physical hazard or a health hazard.

10.10. **Health hazard** means 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 which 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.

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

10.12. **Label** means any written, printed or graphic material displayed on or affixed to containers of hazardous chemicals.

10.13. **Material safety data sheet (MSDS)** means 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.

10.14. **Mixture** means any combination of two or more chemicals if the combination is not, in whole or in part, the result of a chemical reaction.

10.15. **Organic peroxide** means 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.

10.16. **Oxidizer** means a chemical other than a blasting agent or explosive, as defined in 1910.109(a) that initiates or promotes combustion in other materials, thereby causing fire either of itself or through the release of oxygen or other gases.
10.17. **Physical hazard** means 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.

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

10.19. **Readily accessible** means can be accessed by or be made available to an employee during their immediate work shift.

10.20. **Unstable (reactive)** means 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.

10.21. **Use** means to package, handle, react, emit, extract, generate as a byproduct, or transfer.

10.22. **Water-reactive** means 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. The second option presented is based on the ChemTracker inventory system, which is new to MIT. If you use the ChemTracker Inventory, compatibility recommendation are provided. 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.

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 to chemicals together, but can also help to determine appropriate storage for a chemical.

http://response.restoration.noaa.gov/chemaids/react/reactinfo.html (This is a worksheet program you can download).
http://www.ehs.washington.edu/fsosurveys/chemcompat.shtm
http://www.ehs.psu.edu/hazmat/chemical_compatibility.cfm

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 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. For example, if something is an oxidizer and an acid, it should be stored as an oxidizing acid.

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

Part I. Compatibility group

<table>
<thead>
<tr>
<th>Group with Letter Correlation for Scheme Two in Part IV. Below</th>
<th>Hazard</th>
<th>Color code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group I (L)</td>
<td>Flammable Liquids</td>
<td>Red</td>
</tr>
<tr>
<td>Group II (L)</td>
<td>Poisons- volatile</td>
<td>Blue</td>
</tr>
<tr>
<td>Group III (E)</td>
<td>Acids - Oxidizing</td>
<td>Yellow (for reactive)</td>
</tr>
<tr>
<td>Group IV (D)</td>
<td>Acids – Organic and Mineral</td>
<td>Depends on acid (White for corrosive or red for flammable.)</td>
</tr>
<tr>
<td>Group V (C)</td>
<td>Group VI (E)</td>
<td>Group VII (No equivalent)</td>
</tr>
<tr>
<td>------------</td>
<td>-------------</td>
<td>---------------------------</td>
</tr>
<tr>
<td>Bases</td>
<td>Oxidizer – Liquid</td>
<td>Poisons – Non-volatile</td>
</tr>
<tr>
<td>White (corrosive)</td>
<td>Yellow (reactive)</td>
<td>Blue (poison)</td>
</tr>
</tbody>
</table>

**Part II. Storage Group Information**

**Group I: Flammable Liquids**
Includes liquids with flashpoints < 100 F. Examples: all alcohols, acetone, acetaldehyde, acetonitrile, amyl acetate, benzene, cyclohexane, dimethyldichlorosilane, dioxane, ether, ethyl acetate, histoclud, 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.

**Special Note:** All containers of flammable liquids (flashpoint <140F) 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.

**Compatible Storage Groups:** Volatile poisons may be in the same compartment of the flammable cabinet as flammables if bases are not present.

**Group II: Volatile Poisons**
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.

**Compatible Storage Groups:** Volatile poisons may be in the same compartment of the flammable cabinet as flammables if bases are not present.

**Group III: Oxidizing acids**
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:**
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.

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.

**Group IV: Organic and Mineral Acids**
**Examples:** acetic, butyric, formic, glacial acetic, hydrochloric, isobutyric, mercaptoproprionic, 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 also double contained.

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.

**Group V: Liquid Inorganic Bases**
1. **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**
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.

Compatible Storage Groups: None

Group VII: Non-Volatile Liquid Poisons
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).

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
Most metal hydrides react violently with water; some ignite spontaneously in air (pyrophoric). 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, chlorosulonic 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:
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
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:
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 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.

Exceptions: Solid picric or picricsulfonic 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.

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.

References or links for other chemical storage groupings and information:

- Prudent Practices in the Laboratory Handling and Disposal of Chemicals, Cy 1995 Chapter 4.

Contact EHS at 2-3477 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.

**Variation 2:**
Chemical storage plan for lab with freestanding acid cabinet.
## Chemical Storage Table Supplement for Chemical Storage Scheme One SOG (3-09)

<table>
<thead>
<tr>
<th>Group</th>
<th>Properties</th>
<th>Important Notes</th>
<th>Storage</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Group 1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Flammables and Combustibles</strong> <em>(Includes organic acids)</em></td>
<td>Flammable liquids have a flashpoint (FP) below 100°F (38°C).</td>
<td>The MSDS provides the flashpoint for flammable and combustible liquids.</td>
<td>FP ( \leq 140°F ) (60 °C) store in a metal flammable cabinet that is completely enclosed. If vented, the vent must have a flash arrestor.</td>
<td>All alcohols: butanol, ethanol, methanol, isopropanol, etc.</td>
</tr>
<tr>
<td><strong>AKA: organics, solvents</strong></td>
<td>Combustible liquids have a flashpoint above 100°F and below 140°F</td>
<td>Ignition sources include spark from electrical outlet, vacuum pumps, and static electricity.</td>
<td>NO cardboard shipping boxes in the cabinet.</td>
<td>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.</td>
</tr>
<tr>
<td></td>
<td>Flashpoint is the lowest temperature at which a liquid gives off enough vapor to ignite.</td>
<td>Never store in cold rooms or refrigerators (unless the refrigerator is explosion-proof).</td>
<td>Do not store with oxidizers or inorganic acids.</td>
<td>Combustibles: dimethylformamide, formaldehyde</td>
</tr>
<tr>
<td><strong>Peroxide-formers</strong></td>
<td>Highly flammable. May form low-power explosives that are very sensitive to shock, sparks, light, strong oxidizing and reducing agents, friction, and high temperatures.</td>
<td>Read Peroxide-Forming Chemicals SOP</td>
<td>Store with flammables.</td>
<td>Ether (diethyl and isopropyl), tetrahydrofuran, acetaldehyde, etc.</td>
</tr>
<tr>
<td><em>Generally, Group I</em></td>
<td>Distillation, evaporation, or other concentration can present a high risk of explosion. Test for peroxide formation monthly.</td>
<td>Date when received and when opened.</td>
<td>Dispose of as hazardous waste after 12 months.</td>
<td></td>
</tr>
<tr>
<td><strong>Group II (volatile) and VII (non-volatile)</strong></td>
<td>Chronic exposure is a health hazard. Avoid inhalation, skin contact.</td>
<td>Commonly mistaken for a flammable liquid.</td>
<td>OK to store with flammables in flammable cabinet.</td>
<td>Volatile toxics: carbon tetrachloride, chloroform, dimethyl sulfate, halothane, mercaptoethanol, methylene chloride (dichloromethane), phenol</td>
</tr>
<tr>
<td><strong>Toxics</strong> <em>AKA: poisons, organics, halogenated solvents, carcinogens, mutagens, reproductive toxins</em></td>
<td>Many toxic solvents are highly volatile.</td>
<td>Alternative: Any enclosed cabinet or shelf to protect from accidental breakage.</td>
<td>Store containers larger than 1 liter below bench level.</td>
<td>Non-volatile toxics: acrylamide solutions, ethidium bromide, triethanolamine</td>
</tr>
<tr>
<td></td>
<td>Non-flammable (some are combustible).</td>
<td>Store containers larger than 1 liter below bench level.</td>
<td>Do not store with bases.</td>
<td></td>
</tr>
<tr>
<td>Group</td>
<td>Properties</td>
<td>Important Notes</td>
<td>Storage</td>
<td>Examples</td>
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<tr>
<td><strong>Group III</strong>&lt;br&gt;(oxidizing acids)</td>
<td>Oxidizing acids are highly reactive, and may react with each other. Corrosive, burns skin and eyes.</td>
<td>Concentrated (&gt; 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.</td>
<td>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.</td>
<td>Oxidizing inorganic acids: nitric, sulfuric, perchloric, chromic</td>
</tr>
<tr>
<td><strong>Group IV</strong>&lt;br&gt;Mineral Acids and Organic Acids</td>
<td>Corrosive, burns skin and eyes.&lt;br&gt;Organic acids are combustible (FP &gt;100°F&lt;140°F)</td>
<td>Acid mist escapes from closed bottles and builds up inside un-vented cabinets causing corrosion of labels, metal cabinets, etc.</td>
<td>Store in the vented cabinet under fume hood or in a vented stand alone cabinet.&lt;br&gt;Do not store with bases.&lt;br&gt;Store below eye level.&lt;br&gt;It is a good idea to keep hydrofluoric acid in a separate tub or tray to avoid contamination of surfaces.</td>
<td>Mineral acids: hydrochloric, phosphoric, hydrofluoric&lt;br&gt;Organic acids: acetic, acrylic, acetic anhydride, butyric, formic, glacial acetic, isobutyric, mercaptopropionic, trifluoroacetic, etc.</td>
</tr>
<tr>
<td><strong>Group V</strong>&lt;br&gt;Liquid Inorganic Bases&lt;br&gt;AKA: alkaline</td>
<td>Corrosive burns skin and eyes.</td>
<td>Avoid contact with acids and volatile toxics.</td>
<td>Store in a separate cabinet.&lt;br&gt;Alternative: store with other chemicals and keep in a separate tub or tray.&lt;br&gt;Can be stored with flammables if no volatile toxic (halogenated organics) are present.&lt;br&gt;Store below eye level.</td>
<td>Sodium hydroxide, ammonium hydroxide, calcium hydroxide, potassium hydroxide, aqueous ammonia</td>
</tr>
<tr>
<td>Group</td>
<td>Properties</td>
<td>Important Notes</td>
<td>Storage</td>
<td>Examples</td>
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<tr>
<td><strong>Group VI</strong>&lt;br&gt;Oxidizing Liquids&lt;br&gt;(Excluding Oxidizing acids)&lt;br&gt;AKA: reactives</td>
<td>Provides oxygen that feeds fires and makes fires very difficult to extinguish. Oxidizing liquids react with many things potentially causing explosions or corrosion of surfaces.</td>
<td>The oxidizer symbol (a burning O) may be mistaken for a flammable symbol (a flame). Oxidizers are considered ignitable for hazardous waste management purposes.</td>
<td>Store on a separate shelf. Do not store directly on wood shelf or paper. If stored near other chemicals, including other oxidizers keep in a separate tub or tray. Do not store with flammables.</td>
<td>Ammonium persulfate, hydrogen peroxide ≥ 30%</td>
</tr>
<tr>
<td><strong>Group VIII</strong>&lt;br&gt;Pyrophorics and Water Reactives</td>
<td>Ignite spontaneously in air. Water reactives can react with moisture in the air to produce a flammable gas. Metal hydrides react violently with water, some ignite spontaneously in air.</td>
<td>Read Pyrophoric and Water Reactives SOP</td>
<td>Waterproof double containment (the shipping container may be an appropriate second container). Isolate from other chemicals. OK to store with dry chemicals. Do not store with liquid chemicals (oxidizers, flammables, acids, bases, toxics etc.)</td>
<td>Metal hydrides: sodium borohydride, calcium hydride, lithium aluminum hydride, etc. Pyrophorics: borane, diborane, dichloroborane, lithium, phosphorous, 2-furaldehyde, diethyl aluminum chloride, trimethyl aluminum, etc. Water Reactives: aluminum chloride anhydrous, calcium carbide, acetyl chloride, chlorosulonic acid, sodium, potassium, phosphorous pentachloride calcium, aluminum tribromide, calcium oxide, acid anhydrides etc.</td>
</tr>
<tr>
<td>Group IX Dry Solids</td>
<td>Properties</td>
<td>Important Notes</td>
<td>Storage</td>
<td>Examples</td>
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<td></td>
<td>Varies. They are dry, but when wet, may have different properties, depending on the material.</td>
<td>Keep Dry. Indicate where the more toxic materials are located. (See SOP)</td>
<td>Cabinets are suggested, but shelves are O.K. Store above liquids and separate from liquids.</td>
<td>Benzidine, cyanogens, bromide, oxalic acid, potassium hydroxide.</td>
</tr>
</tbody>
</table>

For more information see the Chemical Storage SOP and App A – Storage Scheme One of the SOP. Go to: http://web.mit.edu/environment/ehs/chemical_storage.html

<table>
<thead>
<tr>
<th>Basic Rules</th>
<th>Common Problems</th>
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</thead>
<tbody>
<tr>
<td>- Store in compatible groups. Consult above referenced SOP, manufacturer’s recommendations and MSDS. (To obtain MSDS, Google search: chemical name MSDS, or type MSDS on MIT Home page search to see link to MIT MSDS link page.)</td>
<td>- Oxidizing acids stored with organic acids, e.g. Nitric acid and acetic acid.</td>
</tr>
<tr>
<td>- Minimize chemicals purchased, especially flammables and reactives.</td>
<td>- Oxidizers stored with flammables.</td>
</tr>
<tr>
<td>- Label storage areas, and label all chemicals being stored.</td>
<td>- Acids stored with bases.</td>
</tr>
<tr>
<td>- Store hazardous liquids below eye level.</td>
<td>- Flammables stored in non-flammable refrigerator.</td>
</tr>
<tr>
<td>- Make sure chemical containers are in good condition and are compatible with contents.</td>
<td>- Large quantities of flammables stored outside flammable cabinets.</td>
</tr>
<tr>
<td>- Lids should be tightly closed.</td>
<td>- Corrosives (acids and bases) or other liquids stored above eye level.</td>
</tr>
<tr>
<td>- Secondary containment for floor storage.</td>
<td>- Stock chemicals stored in fume hood.</td>
</tr>
<tr>
<td>- Do not store solids with liquids</td>
<td>- Reactives stored with incompatible chemicals.</td>
</tr>
<tr>
<td>- Do not store items in working space of fume hoods.</td>
<td>- Liquids stored with solids that are incompatible with liquids, e.g. cyanides.</td>
</tr>
<tr>
<td>- Do not store hazardous chemicals in cold rooms</td>
<td>- Anhydrides not stored with secondary containment.</td>
</tr>
<tr>
<td>- Annually discard unused, unwanted, and expired chemical</td>
<td></td>
</tr>
</tbody>
</table>

Note: The compatibility groups are guidelines. There are other options for chemical storage. There are some options for combining chemical groups, as well. Chemtracker uses a different storage system, referred to as Storage Scheme Two, also shown in the Chemical Storage SOP. If you have a specific problem or question regarding chemical storage, please contact EHS at 2-3477, and let them know you have a chemical storage question.
### Part IV. Storage Scheme Two (ChemTracker Scheme)

For more details go to:
[http://www.stanford.edu/dept/EHS/prod/researchlab/lab/storage_group.html](http://www.stanford.edu/dept/EHS/prod/researchlab/lab/storage_group.html)

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


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