

Chapter 5: CHEMICAL STORAGE

Chemical storage areas in academic laboratory settings include central departmental stockrooms, storerooms, laboratory work areas, storage cabinets, refrigerators and freezers. There are established legal requirements as well as recommended practices for storing chemicals. These requirements and guidelines are summarized below in the following sections:

- General requirements
- Segregation of incompatible chemicals
- Specifications for chemical storerooms
- Chemical storage in laboratories (outside of chemical storerooms)
- Additional storage requirements and recommendations for specific hazard chemical classes

General Requirements

1. Every chemical should have an identifiable storage place and should be returned to that location after use.
2. A storage scheme must be developed in each chemical storage area to ensure the segregation of incompatibles and efforts must be made to isolate particularly flammable, reactive, and toxic materials. An exclusively alphabetical storage scheme is prohibited.
3. Chemical storage on benchtops will be minimized in order to reduce the amounts of chemicals unprotected from a potential fire or easily knocked over.
4. Compatible chemicals should be grouped by container size to make it easier to retrieve chemicals and to reduce the possibility of bottle breakage.
5. Chemical storage in hoods will be minimized. Storing containers inside the hood interferes with airflow, reduces and clutters up the work space, and provides fuel in a fire or explosion. Where possible, chemicals will be stored in separate cabinets which vent directly into the fume hood.
6. Labels must be maintained on all stored materials.
7. Stored chemicals must not be exposed to direct sunlight or heat.
8. Storage trays should be used to minimize the spread of a spill.
9. Laboratory refrigerators must never be used to store food.
10. All chemicals containers left out of storage areas must be checked at the end of each workday. Unneeded items must be returned to chemical storerooms or stockrooms.
11. Store acids (inorganic and some organic acids) in a dedicated acid cabinet. Oxidizing acids must be isolated from other acids (i.e., each in its own separate secondary containment).
12. Store flammables in a dedicated flammables cabinet. Acetic acid and acetic anhydride must be stored in a flammable cabinet.
13. Store highly toxic chemicals in a dedicated cabinet.
14. Opening/expiration dates must be assigned to chemicals with the following functional groups/chemical properties:
 - a. Picric acid and Picrates
 - b. Perchlorates
 - c. Peroxides

- d. Peroxidizable materials (aldehydes, ethers, compounds containing benzylic hydrogen atoms). Peroxidizable materials must be tested routinely for peroxides
 - e. Monomers that polymerize violently or become hazardous after polymerization
 - f. Other materials known to deteriorate or become unstable or reactive over time
15. All laboratory personnel, on termination, transfer, or graduation must (in conjunction with the laboratory supervisor and CHO) arrange for the redistribution, removal or safe storage of all hazardous materials remaining in their laboratory.
16. Appropriate spill control, clean-up and emergency equipment must be available wherever chemicals are stored. See Chapter 8 for guidance in choosing these materials.

Segregation of Incompatible Chemicals

Chemicals must not be arranged alphabetically or haphazardly in stockrooms or in laboratory work areas. Alphabetical arrangement of chemicals can inadvertently place two incompatible chemicals next to each other, which in the event that the containers break or leak could react violently. Some examples:

Acetic acid	+	Acetaldehyde	=	explosive reaction
Aluminum metal	+	Ammonium nitrate	=	potential explosive
Cupric sulfide	+	Cadmium chlorate	=	explode on contact
Mercury II oxide	+	Magnesium metal	=	potential explosive
Sodium nitrite	+	Sodium hypophosphite	=	explosive

Numerous approaches can be taken to segregate chemicals in storage. Different approaches may be required depending upon the type and amount of space available for storage and the environmental conditions of the spaces. Major considerations for segregation criteria should include water reactivity and flammability. Special attention must be paid to the following chemicals due to their potential reactivity:

INORGANIC	Nitrates	Nitrites	ORGANIC
Metal azides	Perchlorates	Perchloric acid	Ethers
Peroxides	White phosphorus	Phosphorus pentoxide	Organic azides

Particular attention must be paid to isolating flammable, pyrophoric, peroxidizable, and toxic chemicals. Storage of specific hazard classes of chemicals is discussed in greater detail below.

Chemical Storage Area Specifications

Stockrooms are facilities used for storing relatively large quantities of chemicals for laboratory use.

General specifications for all chemical stockrooms:

- Stockroom access must be strictly limited to specified personnel. All laboratories, preparation rooms, and storeroom/stockrooms must be locked and secured when designated laboratory employees are not present.

- A mechanical exhaust ventilation system must be present and should provide at least 6 air changes per hour (FDNY). Additional local exhaust may be required if activities such as dispensing take place in the storage area.
- Each storage area should have at least 1 large sink, safety shower, eyewash station, and must have an appropriate fire extinguisher with adequate extinguishing capacity.
- Each chemical storage area should have a master control shut-off valve for water, electricity, and utility gas.
- Shelf assemblies must be firmly secured to walls. Weight limits provided by the manufacturer must not be exceeded. Avoid island shelf assemblies.
- Large containers should be stored on lower shelves. No chemicals should be stored above eye level and avoid top shelf chemical storage. Chemicals must not be stored on the floor.
- Metal shelving assemblies should be of heavy gauge construction with a durable baked-on chemically resistant or epoxy finish. Wooden shelves should have chemically resistant coverings. Although wood may be more absorbent to liquids than steel, it is less reactive and more resistant to a wide range of chemicals. Wood shelves should not be used to store nitric acid, perchloric acid or other chemicals that react vigorously with organic materials. Shelves should have anti-roll edges to prevent containers from falling off shelves. Avoid adjustable metal shelf supports or clips and ensure that aisles between shelves are at least 3 feet wide.
- All chemical storerooms and stockrooms must have clearly-marked, unobstructed exits. Each area should have two exits.
- Chemical stockrooms must be well-illuminated so that labels can be easily read.
- No aisle should dead end. Aisles must be kept clear of clutter.
- The environment in stockrooms must be controlled to avoid extremes of temperature and high humidity. Open flames, smoking and localized heating units are not permitted.
- Floors must be kept clean and dry.
- Wherever highly toxic chemicals are stored and could be released, self-contained escape respirators or self-contained breathing apparatus must be made available (see Chapter 8 or Standard Operating Procedures related to respirators).

Flammable Materials Store rooms

The flammable storage limit for laboratories in Davis is 15 gallons; in Science Hall, 25-30 gallons (approximately). Inventories of flammable liquids in quantities that exceed day-to-day laboratory use should be stored in FDNY-permitted flammable storage rooms to minimize the potential harm to persons and property in case of fire. Storage facilities for flammables must meet the following specifications:

- The walls, ceilings, and floors of an inside storage room for flammable materials must be constructed of materials having at least a 2-hour fire resistance.
- All doors between the room and the building should be self-closing Class B fire doors.
- Adequate mechanical ventilation must be provided and controlled from a switch outside the storage room door. Exhaust should be at floor level since flammable vapors tend to sink in air.

- In areas where Class I flammable liquids are stored or dispensed, electrical power, lights, switches, and sockets must be explosion-proof.
- Fan motors and ventilation equipment motors must be non-sparking.
- All smoking and lighting of matches are prohibited.

Chemical storage outside of a chemical stockroom

The nature of laboratory work calls for a certain number/quantities of chemicals to be on hand for easy access. However, all laboratory employees must limit, as much as possible, the amounts of chemicals stored on benchtops, in hoods, or other exposed areas, especially when these chemicals are flammable, combustible, reactive, toxic, or corrosive.

FDNY regulations determine the amount of flammable materials, oxidizing, unstable and reactive chemicals which may be stored in laboratories based upon the fire rating of the room and whether it has a sprinkler system. The following table gives FDNY storage limits for different lab types:

Lab Type	Fire Rating	Fire Protection	Flammable Liquids & VFOs	Flammable Solids	Oxidizing Materials	Unstable/ Reactive
I	2 hours	Sprinklers	30 gallons	15 pounds	50 pounds	12 pounds
II	1 hour	Sprinklers	25 gallons	10 pounds	40 pounds	6 pounds
III	2 hours	No Sprinklers	20 gallons	6 pounds	30 pounds	3 pounds
IV	1 hour	No Sprinklers	15 gallons	3 pounds	20 pounds	2 pounds

** Except for chemical research laboratories, no permit shall be required for laboratories storing or using less than 32 oz., flammable liquids or volatile flammable oils (VFOs), 0.5 lb. oxidizing material and/or 0.15 cubic feet water container capacity of flammable gases.

For example, a laboratory unit with a fire rating of 1 hour that has no sprinkler system (i.e. a Type IV Lab) must not store more than:

- 15 gallons of flammable liquids
- 3 pounds of flammable solids
- 20 pounds of oxidizing materials
- 2 pounds of unstable or reactive chemicals

All lab units in Davis are Type IV.

NFPA Code 45 (Fire Protection for Laboratories Using Chemicals) goes further in describing maximum permissible quantities of flammable and combustible materials outside of approved liquid storage rooms. NFPA recommends limits per lab unit as well as per 100 square feet of laboratory unit in sprinklered and unsprinklered units. Instructional laboratories specifically are allowed only half of the quantity of non-instructional research laboratories.

For example, the maximum quantity of Class I flammables in unsprinklered instructional laboratories including quantities in storage cabinets and safety cans (see below) is 10 gallons per 100 square feet of laboratory space. Research labs would be allowed 20 gallons including quantities in storage cabinets and

safety cans. Storage limits for each FDNY-permitted laboratory are written on the permit posted at the entrance.

Laboratory Supervisors must inventory chemicals in laboratories periodically to ensure that the above described limits are not exceeded. Any problems must be directed to the Departmental Chairperson, the CHO, or other designated individuals.

Flammable Liquids Storage Cabinets

When substantial amounts of flammable liquids are stored on open shelves or work benches it is possible for a small spill to quickly escalate. It is essential that flammable chemicals be isolated from combustibles and kept away from ignition sources. Flammable materials may be stored in flammable storage cabinets which meet OSHA and National Fire Protection Association specifications. These require that cabinet contents are protected from temperatures exceeding 325°F for at least 10 minutes, enough time for personnel to evacuate the area.

Commercial flammable storage cabinets are available to store 30, 46, and 60 gallons of flammable materials. **Note:** maximum capacities for flammable cabinets **exceed** storage limits for all lab types in NYC. In other words, flammable storage cabinets must **never** be filled to capacity.

Cabinets are available with benchtops as the “roof”, or as fume hood base cabinets that can be vented through the fume hood itself.

Cabinets that are separately vented require steel ducting and must never be vented into other rooms of the facility. Designing and installing the proper venting equipment requires technical assistance.

NEVER INSTALL OR REROUTE DUCT WORK WITHOUT FIRST SEEKING QUALIFIED TECHNICAL ADVICE.

Cabinets must be designed and manufactured to meet the following specifications:

- The bottom, top and sides must be of least 18 gauge metal iron and double walled with a one-and-a-half inch air space;
- Joints must be riveted, welded or made tight by equally effective alternative means;
- The cabinet door should have a 3 point lock;
- The door sill should be raised at least 2 inches above the bottom of the cabinet;
- Cabinets must be conspicuously labeled "Flammable - Keep Fire Away!"

Storage Requirements for Specific Hazard Classes of Chemicals: Flammables and Combustibles

Maximum Container Sizes: OSHA and NFPA limit the size of the container for classes of flammable and combustible materials. The more fire resistant a container, the larger it may be.

Container Type	Flammable Liquid Class* (see table below of different Classes)			Combustible Liquid Class*	
	Container Size				
	IA	IB	IC	II	III

Glass	1 pint ^a	1 quart ^a	1 gallon	1 gallon	1 gallon
Metal, other than DOT-approved drums, or approved plastic	1 gallon	5 gallons ^b	5 gallons ^b	5 gallons ^b	5 gallons ^b
Safety can	2 gallons ^b	5 gallons ^b	5 gallons ^b	5 gallons ^b	5 gallons ^b
Metal drums, DOT-approved	5 gallons ^b	5 gallons ^b	5 gallons ^b	60 gallons ^b	60 gallons ^b

^aSizes as large as 1 gallon may be used if the purity of the liquids is adversely affected by storage in metal or if liquid causes excessive corrosion of the container.

^bIn instructional laboratories, no containers for Class I or II liquids can exceed 1 gallon, unless they are stored in safety cans which may be of 2 gallon capacity.

*Flammable and Combustible Class	Flash point range	Boiling point range
Class IA Flammables	<73 ^o F	<100 ^o F
Class IB Flammables	<73 ^o F	>100 ^o F
Class IC Flammables	≥73 ^o F	<100 ^o F
Class II Combustibles	≥100 ^o F	<140 ^o F
Class III Combustibles	≥140 ^o F	N/A

Safety Cans for Flammable Liquids

Portable and approved safety cans should be used whenever possible for storing flammable liquids. Safety cans are available in a variety of sizes and materials and are designed to prevent explosions in the event of a fire by using a spring-loaded spout cover which opens to relieve internal pressure. These cans will not leak if tipped over. Some also have flame arresters in the spout to prevent flame propagation into the cans. Flammable liquids purchased in large containers should be re-packed into smaller safety cans for distribution to laboratories.

Flammable and Other Compressed Gases

- The names of compressed gases must be prominently posted;
- Storage of flammable gases in laboratories is not permitted, except in ongoing procedures requiring their use (e.g. gas chromatography with a flame ionization detector);
- Flammable gas cylinders should be stored separately from other types of compressed gases;
- Cylinders of incompatible gases must be segregated by distance. Group cylinders by the type of gas (e.g. toxic, corrosive, etc.);
- Empty cylinders should be separated from full cylinders and labeled "empty" or "MT";
- All compressed gases must be stored away from direct or localized heat in well-ventilated, dry areas, and away from areas where heavy items could strike them (e.g. near elevators or service corridors);
- All compressed gases, including empty cylinders, must be secured in an upright position with chains, straps or special stands, and must be capped when stored or moved;
- A hand truck must be available for transporting gas cylinders to and from storage areas.

Oxidizers

Definition: Oxidizers are any solid or liquid that readily yields oxygen or other oxidizing gas or that readily reacts to oxidize combustible materials. Strong oxidizers can present fire and explosion hazards on contact with organic compounds or other oxidizable materials. Some examples are:

Nitrates	Iodates	Peroxides
Chlorates	Per- and peroxy compounds	Hydrogen peroxide >8%
Bromates	chromates	Calcium hypochlorite

Storage considerations:

Oxidizers must be stored away from incompatible materials such as:

Flammable/combustible materials	paper trash bins	organic liquids
greases	finely divided metals	other oxidizers

Nitric acid, sulfuric acid, and perchloric acid should be stored in separate rooms, cabinets or break-resistant containers, using acid-resistant trays for secondary containment.

Some oxidizers can undergo explosive reactions when catalyzed or exposed to heat, shock, or friction and must be physically separated from other chemicals. Examples are:

ammonium perchlorate	perchloric acid solutions (> 72.5% by weight)
ammonium permanganate	
hydrogen peroxide (> 91% by weight)	potassium superoxide

Strong oxidizing agents must be stored and used in glass or other inert containers. Corks and rubber stoppers must not be used.

Peroxides and Chemicals Which Tend to Form Peroxides

Storage conditions

These must be stored in airtight containers in a dark, cool and dry place.

To minimize the rate of decomposition, peroxides and peroxidizable materials should be stored at the lowest possible temperature consistent with their solubility and freezing point. Liquid or solutions of peroxide should not be stored at or lower than the temperature at which the peroxide freezes or precipitates, becoming extremely sensitive to shock and heat.

Toxic chemicals

Toxic chemicals can cause either severe short-term acute health effects and/or severe long-term chronic health effects. These include corrosives, dehydrating agents, carcinogens, potential carcinogens, allergic

sensitizers, and reproductive hazards. They also include chemicals known to affect the nervous system, the liver, the kidneys, or the respiratory system.

- These chemicals must be stored in unbreakable chemically-resistant containers;
- Adequate ventilation must be provided in storage areas especially for toxics with high vapor pressures;
- All dispensing of these materials must be conducted in a fume hood;

Other information about handling extremely toxic chemicals can be found in Chapter 6.