

Guidelines for Chemical Storage

Chapman University Environmental Health & Safety

Proper chemical storage is a necessity for any laboratory using hazardous materials. Typically many of the classification systems group hazardous materials by compatibility based on hazard class or chemical family, however, there can be as many as 40 to 50 different categories using this type of system. The number of categories or groups in which a chemical can be organized will vary depending on space availability and secondary containerization. By utilizing the Chem Tracker Chemical Inventory System based on Stanford University guidelines, the system classifies storage groups independent of main hazard classes, which allows the number of Storage Groups to be as few as possible. Storage Groups are groups of chemicals that will not react violently if mixed together. It is possible that two chemicals designated to two different storage groups are compatible because the groupings, by their nature, are generalizations. Based on specific knowledge or information, two chemicals from different storage groups could be stored together.

Storage Groups

- Storage groups are groups of chemicals that if stored together will not react violently if mixed. A storage group code (A-X) is automatically assigned to each chemical included in the ChemTracker Chemical Inventory System.
- The storage group determination of any material can be determined by referring to the "Hazards Identification" and "Toxicological Information" sections of the Material Safety Data Sheet (MSDS) or by referring to the chemical safety information available through ChemTracker via EH&S' assistance x2888 or swift@chapman.edu
- Storage Group Codes are used for storing solids, liquids and gases.
- Chemicals with multiple hazards are stored according to the primary hazard.
- See Table 1 for the storage group codes, descriptions and examples.

Table 1

Code	Storage Groups	Examples
A	Compatible Organic Bases	BIS TRIS, Diethylamine, Imidazole, Triethanolamine
B	Compatible Pyrophoric and Water Reactive Materials	Tert-Butyllithium, Sodium Borohydride
C	Compatible Inorganic Bases	Sodium Hydroxide, Ammonium Hydroxide
D	Compatible Organic Acids	Acetic Acid , Maleic Acid
E	Compatible Oxidizers including Peroxides	Nitric Acid, Periodic Acid, Perchloric Acid, Potassium Permanganate
F	Compatible Inorganic Acids not including Oxidizers or Combustibles	Phosphoric Acid, Hydrochloric Acid, Sulfuric Acid Hydrofluoric Acid
G	Not Intrinsically Reactive or Flammable or Combustible	Acrylamide, Sodium Bisulfate, Coomassie Blue, Sodium Chloride
J	Poison Compressed Gases	Ethylene Oxide, Hexafluoropropylene, Sulfur Dioxide, Trifluoromethyl Iodide Dioxide, Trifluoromethyl Iodide
K	Compatible Explosive or other highly unstable materials	Picric Acid Dry, Tetrazole, Ammonium Permanganate
L	Non-Reactive Flammables and Combustibles, including solvents	1-Butanol , 1-Propanol, Acetic Anhydride , Acrolein, Formamide, Sigmacote
X	Incompatible with All Other Storage Groups	Sodium Azide , Picric Acid Moist, Arsine

Hazardous chemicals must be stored, labeled and inventoried properly to avoid confusion or mistaken identity of a chemical, to provide separation of incompatible materials, and to provide information for emergency response personnel.

Criteria for Storage Area

- Store chemicals inside a closeable cabinet or on a sturdy shelf with a front-edge lip to prevent accidents and chemical spills.
- Secure shelving to the wall or floor.
- Ensure that all storage cabinets have doors which properly latch. In some cases when storing Controlled Substances or Acutely Toxic cabinets should be lockable.
- Ventilate storage areas adequately.
- Label the storage location with the appropriate hazard and assigned Storage Group.

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Organization

- Organize chemicals first by compatibility not alphabetically.
- Only store in alphabetical order once chemicals are in appropriate storage groups.
- Larger chemical containers should be stored towards the back and smaller ones should be stored up front where they are visible.

Chemical Containers

- Must be clearly labeled and in good condition.
- Labeled with purchase date, room, location and shelf number.
- Chemicals stored in non-manufacturer containers must have full chemical name and hazard listed.
- Should be in good condition-showing no signs of oxidation (no leaking, cracked caps, rusting, nor have any crystals around their necks.)

Secondary Containment

- Used to separate incompatible chemicals.
- Should be used for ALL liquid chemicals.
- Must have the capacity to hold the amount of materials to be contained.
- Must be capable of holding any spilled material until the spill can be cleaned up.
- Must be compatible with the chemical stored. For example Hydrofluoric acid should be stored in a secondary container constructed of polyethylene.

Chemical Storage and Segregation

- Separate liquids from solids.
- When possible utilize separate cabinets for storage groups.
- When space does not allow storage groups to be stored separately from each other, multiple groups can be stored on the same shelf or within the same storage cabinet if each group is segregated by secondary containment as outlined in the diagram below.

STORAGE GROUPS

Store chemicals in separate secondary containment and cabinets
Find Storage Group information in Chemtracker.

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 Inherently 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

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.

Note: Group J is not currently stored at this time. **Contact EH&S x2888** or swift@chapman.edu prior to purchasing materials for the following groups: J, K and X. Examples of other materials which should be stored separately would be Acutely/Severely Toxic, Select Carcinogens and Reproductive Toxins along with any Controlled Substances.

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Table 2 below lists some examples of chemicals for the different Storage Groups

Table 2

Chemical	Group	Chemical	Group	Chemical	Group
1-Butanol or 2-	L	Ficoll	G	Propylene Oxide	L
1-Propanol	L	Formaldehyde	L	Pump Oil	L
2-Mercaptoethanol	L	Formamide	L	Pyridine	A
Acetic Acid, Glacial (flammable)	D	Formic Acid (88%)	D	SDS (Sodium Lauryl Sulfate) (in solution G)	L
Acetic Anhydride	L	Geopen	G	Sigmacote	L
Acetone	L	Glutaraldehyde	G	Sodium Acetate	G
Acetonitrile	L	Glycerol	L	Sodium Azide	X
Acetaldehyde	L	Glycine	G	Sodium Bicarbonate	G
Acrolein	L	Guanidine Hydrochloride	G	Sodium Bisulfate	G
Acrylamide	G	Guanidine Thiocyanate	C	Sodium Bisulfite	G
Agarose	G	Halothane, Isoflurane	G	Sodium Borate	G
Ammonium Acetate	G	HEPES	G	Sodium Borohydride	B
Ammonium Chloride	G	Hexanes	L	Sodium Carbonate, Anhydrous	G
Ammonium Formate	G	Hydrochloric Acid	F	Sodium Chlorate	E
Ammonium Hydroxide	C	Hydrogen Peroxide, 90%	E	Sodium Chloride (NaCl)	G
Ammonium Nitrate	E	Hydrogen Peroxide, <5%	G	Sodium Citrate, Dihydrate	G
Ammonium Persulfate	E	Imidazole	A	Sodium Dichromate, Dihydrate	E
Ammonium Sulfate	G	Isobutyl Alcohol	L	Sodium Hydroxide (NaOH)	C
Ammonium Sulfide	L	Isopentane	L	Sodium Hypochlorite	E
Benzene	L	Isopropanol	L	Sodium Hypochlorite solution (i.e. Bleach)	G
BIS & BIS-Acrylamide	G	Magnesium Chloride	G	Sodium Phosphate	G
BIS TRIS	A	Magnesium Sulfate	G	Sodium Sulfide, Anhydrous	B
Borax	G	Maleic Acid	D	Succinic Acid	D
Boric Acid	G	Methanol	L	Sucrose	G
Calcium Chloride	G	N-Methyl-2-Pyrrolidone	L	Sulfuric Acid	F
Chloroform	G	N,N Dimethylformamide	L	Tannic Acid	D
Chromerge	E	Nitric Acid	E	TEMED	A
Citric Acid	D	P-Dioxane	L	TES free acid	G
Coomassie Blue	G	Paraformaldehyde	L	Tetracycline	G
Dextrose	G	Perchloric Acid	E	Tetrahydrofuran	L
Dichloromethane	G	Periodic Acid	E	Trichloroacetic Acid	D
Diethylamine (flammable)	A	Permout	L	Toluene	L
Diethyl Pyrocarbonate	L	Phenol	L	Triethanolamine	A
Dimethyl Popop	G	Phosphoric Acid	F	TRIS	A
Dimethyl Sulfoxide (DMSO)	L	Picric Acid dry (<10% H ₂ O)	K	Triton X-100	G
Drierite	G	Picric Acid moist (10-40% H ₂ O)	X	Trizol	L
EcoLume, UniverSOL, BetaMax, CytoScint, Scintisafe, Econo-Safe, Ecoscint, Opti-fluor	L	Picric Acid soln (1-4%)	X	TWEEN 20	G
EDTA (in solution G)	D	Piperidine	A	Urea	G
Ethanol	L	Pipes, Free Acid	G	WD-40	L
Ethanolamine	A	Potassium Acetate	G	Xylenes	L
Ethers	L	Potassium Chloride	G	Zinc Chloride	G
Ethidium Bromide	G	Potassium Cyanide	C		
Ethyl Acetate	L	Potassium Hydroxide (KOH)	C		
Ethylene Glycol	L	Potassium Phosphate	G		
		PPO	G		
		Propionic Acid	D		

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Practices

- Materials and their containers should be inspected routinely, a minimum of 6 months per the City of Orange Fire Department.
- Indications for disposal include:
 - Cloudiness in liquids
 - Material changing colors
 - Evidence of liquid in solids or solid in liquids
 - Signs of container leakage
 - Indication of pressure build up within container
 - Obvious container deterioration
 - Peroxide formation or oxidation
- Every chemical should have an identifiable storage place and should be returned to that designated storage group location after each use.
 - After each use, carefully wipe down the outside of the container with paper towel.
- **Never store chemicals from different Storage Groups in the same container.**
- Chemical containers should be turned with the labels facing out so they can be easily read.
- Chemicals should not be stored above eye level and when practical store on lower shelves.
- Avoid storing chemicals on the floor or under sinks.
- Chemical storage in hoods should be minimized to avoid blocking rear baffles and interfering with airflow into the hood.
- Chemical storage on bench tops should be minimized in order to reduce the amounts of chemicals unprotected from a potential fire and to prevent them from being easily knocked over.
- Do not store chemicals in offices, domestic or personal refrigerators.
- Inventory the materials stored in the refrigerator frequently and defrost occasionally to prevent chemicals from becoming trapped in the ice formations.
- Although the City of Orange Fire Department set chemical storage limits on all chemical classifications, their primary focus is concerning flammable liquids, flammable gases and Extremely/Acutely/Severally Toxic materials.
- Physically inventory all chemicals on an annual basis and update ChemTracker data base as soon as possible for any additions, deletions or any changes including the room, location and shelf locations.
 - EH&S must be notified immediately about any changes regarding compressed gas cylinders or materials in Group X per City of Orange Fire Department requirements.
 - Once all chemical inventories are reviewed which must take place on an annual basis, EH&S will provide a copy of the Storage Groups and hazards classes for each room. This list will be maintained in the Laboratories "Laboratory Procedures and Safety Manual."

Storage Group-Specific Requirements

- **Corrosive (Group A,C,D and F)**
 - Store corrosive chemicals in dedicated corrosion resistant and ventilated cabinets whenever possible.
 - Secondary containment must be used when storing acids on bare metal.
 - Organic acids (Group D), such as Acetic acid, Lactic acid, and Formic acid (Group D), are considered combustible and corrosive and can be stored in flammable storage cabinets.
 - Do not store acids near any cyanide or sulfide containing chemicals in order to prevent the generation of highly toxic hydrogen cyanide or hydrogen sulfide gases.
 - Do not store concentrated acids next to household bleach, as mixing will generate highly toxic chlorine gas. When stored next to ammonium hydroxide, any potential mixing will generate highly toxic chlorinated amine gases.

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- **Water-Reactive and Pyrophoric (Group B)**
 - Water reactive chemicals must be stored in a closed water-tight container and in a manner to prevent direct contact from water (i.e., not under sinks or on open shelving) and for those stored in the basement away from fire sprinkler systems.
 - They should be segregated from any corrosives and aqueous liquids.
 - The storage area for water-reactive chemicals must be labeled "Water-Reactive Chemicals."
 - Prevent pyrophoric chemicals from contacting air by taking extreme care to prevent containers from leaking or breaking. For additional protection, consider keeping the chemicals in the manufacturer's original shipping package (i.e., surrounded by vermiculite inside a metal can).
- **Oxidizers (Group E)**
 - Do not store oxidizing acids (such as perchloric acid, nitric acid) on wooden shelves or in cardboard boxes.
 - Segregate oxidizing acids (Group E) (nitric, perchloric, chromic acid, chromerge) from organic acids (acetic, formic, etc.) to prevent fires.
- **Flammable (Group L)**
 - Store flammables in approved storage cabinets or in safety cans.
 - The capacity of glass containers shall not exceed one (1) gallon. Metal containers are required for storage of flammable liquids exceeding one gallon.
 - The capacity of a container shall not exceed one liter when stored outside of a cabinet.
 - A maximum of ten (10) gallons of flammable/combustibles materials/wastes may be stored outside of approved flammable storage cabinets per zone.
 - Zone 1 Rooms 406 and 412
 - Zone 2 Rooms 403, 219 and 428
 - Zone 3 Rooms 404, 427 and 439
 - Zone 4 not including room 300 and the balance of the floor area
 - Room 128 is excluded since it is designed and maintained in accordance with the requirements of an approved liquid storage room
 - The basement is its' own separate area
 - Storage limitations for liquids is based on the following classifications

Term	Class	Flash Point	Boiling Point Rating	NFPA
Flammable	IA	<73 F°	<100° F	4
Flammable	IB	<73 F°	≥100° F	3
Flammable	IC	≥73 F°	<100° F	3
Combustible	II	≥100F°	>100° F	2
Combustible	IIIA	≥140F°	<140F°	2
Combustible	IIIB	≥200 F°	<200 F°	1

- Keep away from all ignition sources such as open flames, hot surfaces, direct sunlight and spark.
- Flammable materials or gases are prohibited from use in the basement.
- Store in vented flammable cabinets whenever possible (e.g. under hoods).
- Explosion-proof or flammable-proof refrigerators must be utilized when flammable liquids must be refrigerated. The use of standard/domestic refrigerators to store flammable liquids is prohibited.
- Peroxide-forming chemicals are typically classified as Flammables (Group L). In addition to the flammable specific storage requirements, peroxide-forming chemicals must meet the following requirements
 - Write the date received, opened and expired on all containers.
 - Store in airtight containers in a dark, cool, and dry place.
 - Do not store in direct sunlight as light can accelerate the chemical reactions that form peroxides.
 - Never store peroxide formers in a freezer because a change from solid to a liquid can cause detonation.
 - Dispose peroxide forming chemicals as Hazardous Waste before the expiration date printed on the label.

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- **Compressed Gas (Group E, G and L)**
 - Limit the quantity of compressed gas cylinders on site to what will be used within a reasonable period of time. Only one extra cylinder of the same type of gas can be stored at any one time.
 - Store cylinders upright and secure them with a chain, strap, or wall mount to a stationary building support at 1/3 and 2/3 of the length of the cylinder to prevent it from tipping or falling.
 - Store cylinders in a dry, well-ventilated area away from flames, sparks, or any source of heat or ignition.
 - Place cylinders facing outward or in such a manner that the label and marking can be seen.
 - Place cylinders in a location where they will not be subject to mechanical or physical damage, heat, or electrical circuits to prevent possible explosion or fire.
 - Mark the cylinder storage areas with proper precautionary signs, such as “Storage of flammable, oxidizing, or toxic materials.”
 - Caps used for valve protection should be kept on the cylinders at all times, except when the cylinder is actually being used or charged. Cylinder valves should remain closed.
 - Segregate empty cylinders from full cylinders.
 - When empty cylinders are to be returned to the vendor, mark them “Empty”.
- **Explosives or other Highly Unstable Materials (Group K)**
 - Consult *EH&S x2888* or swift@chapman.edu prior to purchasing or handling.
- **Incompatibles with ALL other storage groups (Group X)**
 - Consult *EH&S x2888* or swift@chapman.edu prior to purchasing or handling.
 - Examples of other materials which should be stored separately and or for regulatory purposes would be Acutely/Severely Toxic, Select Agents/Carcinogens and Reproductive Toxins, along with any Controlled Substances.

There may be certain circumstances when it is not possible to use the **Storage Group** method for segregation since all materials must be stored in secondary containment. When the use of secondary containment is not feasible due to configuration of the laboratory, cabinets or storage areas sizes, the materials may be segregated by their main hazard or chemical family. The chemical storage groups in **Table 3** on the next page offer another alternative for suggestive shelf storage patterns separating chemicals into Inorganic, Organic, Flammable and Toxic groups.

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Table 3
Chemical Storage of Inorganic and Organic Groups

Inorganic

1. Metal, Hydride
2. Halides, Halogens, Phosphates, Sulfates, Sulfites, Thiosulfates
3. Amides, Azides*, Nitrates* (except Ammonium nitrate), Nitrites*, Nitric acid
4. Carbon, Carbonates, Hydroxides, Oxides, Silicates
5. Carbides, Nitrides, Phosphides, Selenides, Sulfides
6. Chlorates, Chlorites, Hydrogen Peroxide*, Hypochlorites, Perchlorates*, Perchloric acid*, Peroxides
7. Arsenates, Cyanates, Cyanides
8. Borates, Chromates, Manganates, Permanganates
9. Acids (except Nitric acid which should be stored by itself)
10. Arsenic, Phosphorous*, Phosphorous Pentoxide*, Sulfur

Organic

1. Acids, Anhydrides, Peracids
2. Alcohols, Amides, Amines, Glycols, Imides, Imines, Sugars
3. Aldehydes, Esters, Hydrocarbons, Oils
4. Ethers*, Ethylene oxide, Halogenated hydrocarbons, Ketenes, Ketones
5. Epoxy compounds, Isocyanates
6. Azides*, Hydroperoxides, Peroxides
7. Nitriles, Polysulfides, Sulfides, Sulfoxides
8. Cresols, Phenols

Note: *Chemicals deserving special attention due to their potential instability

Inorganic #10 Arsenic, Phosphorous, Phosphorous Pentoxide, Sulfur	Inorganic #7 Arsenates, Cyanates, Cyanides STORE AWAY FROM WATER
Inorganic #2 Halides, Halogens, Phosphates, Sulfates, Sulfites, Thiosulfates	Inorganic #5 Carbides, Nitrides, Phosphides, Selenides, Sulfides
Inorganic #3 Amides, Azides, Nitrates, Nitrites EXCEPT Ammonium nitrate STORE AMMONIUM NITRATE AWAY FROM ALL OTHER SUBSTANCES	Inorganic #8 Borates, Chromates, Manganates, Permanganates
Inorganic #1 Hydrides, Metals STORE AWAY FROM WATER. STORE ANY FLAMMABLE SOLIDS IN DEDICATED CABINET	Inorganic #6 Chlorates, Chlorites, Hypochlorites, Hydrogen Peroxide, Perchlorates, Perchloric acid, Peroxides
Inorganic #4 Carbon, Carbonates, Hydroxides, Oxides, Silicates	Miscellaneous
Inorganic #9 CABINET Acids, except Nitric	

Organic #2 Alcohols, Amides, Amines, Glycols, Imides, Imines, Sugars STORE FLAMMABLES IN A DEDICATED CABINET	Organic #8 Cresols, Phenol
Organic #3 Aldehydes, Esters, Hydrocarbons, Oils STORE FLAMMABLES IN A DEDICATED CABINET	Organic #6 Azides, Hydroperoxides, Peroxides
Organic #4 Ethers, Ethylene oxide, Halogenated Hydrocarbons, Ketenes, Ketones STORE FLAMMABLES IN A DEDICATED CABINET	Organic #1 Acids, Anhydrides, Peracids STORE CERTAIN ORGANIC ACIDS IN ACID CABINET
Organic #5 Epoxy compounds, Isocyanates	Miscellaneous
Organic #7 Nitriles, Polysulfides, Sulfides, Sulfoxides, etc.	Miscellaneous
FLAMMABLE STORAGE CABINET	
FLAMMABLE ORGANIC #2 Alcohols, Glycols, etc.	
FLAMMABLE ORGANIC #3 Hydrocarbons, Esters, etc.	
FLAMMABLE ORGANIC #4	
	POISON STORAGE CABINET Toxic substances

Suggested arrangements of compatible chemical families on shelves in chemical storage room or laboratory area. Reference Flinn Chemical Catalog, School Chemistry Laboratory Safety Guide, CDC, NIOSH.