VI. Chemical Storage

Storage related injuries are one of the major sources of accidents in the science classroom and laboratory. Storage related accidents are not only health hazards, they can also be costly. This section concentrates on effective ways of maintaining a safe working environment regarding proper storage of your chemicals.

Fundamental Needs in Chemical Storage

- **Safe access and use by individuals**
- **Minimize chemical interactions**
- **Regulatory compliance**
- **Practical inventory**

Proper storage of chemicals will assist in providing a safe and efficient teaching atmosphere in the laboratory and classroom. It is essential to take and maintain an inventory of your chemicals. Inventory the chemicals in your laboratory every month. Replace worn and damaged labels.

During this inventory, inspect each chemical for deterioration. Deterioration in storage of a specific chemical cannot be specified completely as there are many factors that affect a chemical's life. However many chemicals will show indications of a change in quality. If the chemical shows any signs of the following it should be safely disposed of. If there are any questions regarding how a chemical looks, call Ward's Science for assistance.

Slightly cloudy liquids
Darkening or change in color
Spotting on solids
Caking of anhydrous materials
Existence of solids in liquids
Existence of liquids in solids
Pressure building up in containers
Evidence of reaction with water
Corrosion or damage to the container

There is a good chance that there are chemicals in storage that will never be used. Excess storage of chemicals is never a prudent practice. Dispose of unneeded chemicals, including those that tend to form peroxides, become more reactive with time, and/or are approaching the end of their shelf lives. Follow the chemical disposal applicable regulatory agencies laws for disposal and as defined in *Section XIV – Chemical Disposal* of this manual.

Determining which chemicals to keep is influenced by what demonstrations you will be performing, the chemical shelf life, and the hazardous nature of the chemical. Whether you are setting up a chemical storage area anew or analyzing an existing storage space, the storage principles described in this section should be considered in the final design. Employing these recommendations is essential in creating and maintaining safe storage. This section defines storage as it relates to safe handling and placement of chemicals in the storage room. For information on the design of a chemical storage room please reference *Section VIII – Planning Your Learning Space*.

Storage Guidelines

1. Store minimum quantities needed

Smaller package sizes mean less risk. See *Section II – Purchasing* for further details. Smaller packages also mean fresher chemicals and better experiments.

Ward's Science recommends purchasing the smallest size bottle that meets your needs for the upcoming school year, particularly for hazardous chemicals, anhydrous salts, and any chemical with an 18-month or less shelf life. In addition, new packaging techniques such as pre-measured concentrated solutions and 25 g or less packages should be investigated, both to minimize storage requirements and to minimize disposal requirements.

Adopting microscale techniques will also dramatically decrease your chemical needs.

2. Storing chemicals by compatibility

One of the main problems in chemical storage, and in which is a regular method used, is storing chemicals randomly or alphabetically.

By far the worst storage system involves no system at all or random storage. With this system, there are no restrictions to where chemicals are stored and no limit to the number of adverse reactions that may arise due to incompatible contacts. This is a laboratory waiting for a disaster to happen.

While storing chemicals alphabetically is better than randomly, there is still a great potential of incompatible substances coming in physical contact, particularly during an emergency situation. There are numerous examples that illustrate the problems associated with storing chemicals alphabetically. Many chemicals which may be stored next to one another alphabetically would severely react if they came in contact with one another. The following is a list of but a few of these possibilities:

- **Acetic acid and acetaldehyde** – Acetic acid will cause the acetaldehyde to polymerize, releasing large amounts of heat.
- **Aluminum metal and ammonium nitrate** – This combination will result in a potential explosion.
- **Ammonium nitrate and acetic acid** - This mixture will ignite.
- **Lead perchlorate and methanol** – This is an explosive mixture if agitated.
- **Nitric acid and nitrobenzene** - This mixture may detonate.
- **Silver oxide and sulfur** – This is a potentially explosive mixture.

See Brethericks' *Handbook of Reactive Chemical Hazards, 1999*, or NFPA 491M: *Manual of Hazardous Chemical Reactions for additional information.*

Ward's Science recommends that storage of chemicals be completed based on compatibility. The ten most commonly used compatibility groups are flammables, oxidants, reducers, concentrated acids, concentrated bases, water reactives, extreme toxics, peroxide formers, pyrophorics and gas cylinders. The first five groups are separated / segregated to avoid accidental contact with an incompatible material that could result in a violent or explosive reaction. Water reactives are isolated to lessen the probability of their involvement in a fire situation. Extreme toxics and regulated materials (carcinogens) are segregated to provide some degree of control over their distribution. Peroxide formers should be stored in a cool, dark environment, whereas pyrophorics need only contact with air to burst into flames and must be isolated. Gas cylinders possessing high kinetic energy due to the compressed nature of the gas should also be isolated.

How the chemical groups are divided and assigned depends largely upon the amount of space available. The risk associated with incompatible chemicals coming into contact must be avoided wherever chemicals are handled or stored.

2.1 Chemical Storage Based on Hazard Color Coding

Ward's Science recommends establishing storage space and separating chemicals according to similar hazards, such as flammability, corrosivity, sensitivity to water or air, and toxicity. The following major categories of chemicals and color codings are strongly recommended as a starting point for determining storage:

- **Area 1: LOW HAZARD- Green**
  - Suitable for general storage area
- **Area 2: FLAMMABLES- Red**
  - Store in corrosion-proof area
  - Separate
    - Water compatible flammables
    - Water incompatible flammables
- **Area 3: CORROSIVES**
  - Separating:
    - Acids (except nitric)
    - Nitric acid (isolate)
    - Strong bases
- **Area 4: OXIDIZERS-Yellow**
  - Store away from flammables and combustibles
- **Area 5: POISONS- Blue**
  - Secure in poisons area

The color-coding system used on all Ward's Science chemical containers is one most commonly used in industrial operations and research institutions. It is also the system most commonly used by chemical suppliers throughout the world. The colors indicate generally compatible chemicals. Segregating chemicals by color code allows basic classification by hazard type.

In addition, some items need separate storage. Examples of item that need separate storage are nitric acid and sodium metal. Nitric acid should be stored in an isolation compartment within an acid storage cabinet. Sodium and potassium metals are supplied under oil in a bottle that is in turn enclosed in a sealable can. The can provides isolation for the chemical.

In all cases classification is done based upon the potential interactions of the chemical.

Where large amounts of organic and inorganic chemicals are present, it may be easier to classify chemicals whether they are organic or inorganic first, and then classify by color code. This can provide an extra level of safety with materials that could interact.

2.2 Storage by Compatible Groups (An Alternative Storage Method)

The following chart was taken from the United States Coast Guard's *CHRIS Hazardous Chemical Data*. The chart shows chemicals broken into 24 segregated reactivity groups. Also included are examples of each *r*eactivity group. This is an example of a very complex storage system, a system that can be difficult to administer if all personnel using the storage system are not totally committed to making the system work.

This system is useful when a very large number of chemicals are stored, as in a central chemical storage area in a large research institution.

Group 1 : Inorganic Acids	
Chlorosulfonic acid	Hydrochloric acid
Hydrofluoric acid	Hydrogen chloride
Hydrogen fluoride	Nitric acid
Sulfuric acid	Phosphoric acid
Group 2 : Organic acids	
Acetic acid	Butyric acid
Formic acid	Propionic acid
Group 3 : Caustics (basic)	
Sodium hydroxide	Ammonium hydroxide solution
Group 4 : Amines and Alkanolamines	
Aminoethylethanolamine	Aniline
Diethanolamine	Diethylamine
Dimethylamine	Ethylenediamine
2-Methyl-5-ethylpyridine	Monoethanolamine
Pyridine	Triethanolamine
Triethylamine	Triethylenetetramine
Group 5 : Halogenated Compounds	
Allyl chloride	Carbon tetrachloride
Chlorobenzene	Chloroform
Methylene chloride	Monochlorodifluoromethane
1,2,4-Trichlorobenzene	1,1,1-Trichloroethane
Trichloroethylene	Trichlorofluoromethane
Group 6 : Alcohols, Glycols and Glycol Ether	
1,4-Butanediol	Butanol (iso, n, sec, tert)
Diacetone alcohol	Diethylene glycol
Ethyl alcohol	Ethyl butanol
Ethylene glycol	Furfuryl alcohol
Isoamyl alcohol	Isooctyl alcohol
Methyl alcohol	Methylamyl alcohol
Nonanol	Octanol
Propyl alcohol (n-, iso-)	Propylene glycol

Group 7 : Aldehydes	
Acetaldehyde	Acrolein
Butyraldehyde	Crotonaldehyde
Formaldehyde	Furfural
Paraformaldehyde	Propionaldehyde
Group 8 : Ketones	
Acetone	Acetophenone
Diisobutyl ketone	Isophorone
Mesityl oxide	Methyl ethyl ketone
Group 9 : Saturated Hydrocarbons	
Butane	Cyclohexane
Ethane	Heptane
Hexane	Isobutane
Methane	Nonane
Paraffins	Paraffin wax
Pentane	Petroleum ether
Group 10 : Aromatic Hydrocarbons	
Benzene	Cumene
Dodecyl benzene	Ethyl benzene
Naphtha	Naphthalene
Toluene	Xylene
Group 11 : Olefins	
Butylene	1-Decene
1-Dodecene	Ethylene
1-Heptene	1-Hexene
1-Tridecene	Turpentine
Group 12 : Petroleum Oils	
Asphalt	Gasolines
Jet fuels	Kerosene
Oils	Mineral Oil
Group 13 : Esters	
Amyl acetate	Butyl acetates
Castor oil	Cottonseed oil
Dimethyl sulfate	Dioctyl adipate
Ethyl acetate	Methyl acetate
Group 14 : Monomers and Polymerizable Esters	
Acrylic acid	Acrylonitrile
Butadiene	Butyl acrylate
Ethyl acrylate	Isodecyl acrylate
Isoprene	Methyl acrylate
Group 15 : Phenols	
Carbolic acid	Cresote
Cresols	Phenol

Group 16 : Alkylene Oxides	
Ethylene oxide	Propylene oxide
Group 17 : Cyanohydrins	
Acetone cyanohydrin	Ethylene cyanohydrin
Group 18 : Nitriles	
Acetonitrile	Adiponitrile
Group 19 : Ammonia/ Ammonium Hydroxide	
Group 20 : Halogens	
Group 21 : Ethers (including THF)	
Group 22 : Phosphorus, Elemental	
Group 23 : Sulfur, Molten	
Group 24 : Acid Anhydride	
Acetic anhydride	Propionic anhydride

2.3 Assigning a Storage Classification to a New Chemical

To assign chemicals to a specific storage area based on chemical hazards use the Ward's Science Safety Data Sheet (SDS) to determine this information. The chemical SDS and label shall be used in determining whether the material is a fire hazard, health hazard or reactivity hazard. See *Section IV* for further information.

Many chemicals have multiple hazards and a decision must be made as to which storage area would be most appropriate for each specific chemical. Use the following to prioritize your determination. (Note: Definitions of the characteristics and associated hazards can be found in *Sections IV and IX.)*

1. Flammability characteristics of the material. If the material is flammable, it should be stored in a flammables cabinet.
2. If the material will contribute significantly to a fire (i.e., oxidizers), it should be isolated from the flammables. Always isolate water reactive material away from potential contact with water.
3. Corrosiveness of the material. Store accordingly.
4. Toxicity of the material. In some cases, certain chemicals should be isolated within a storage area. For instance, a material that is an extreme poison but is also flammable, should be locked away in the flammable storage area to also protect it against accidental release.

There will always be some chemicals that will not fit into only one category or another, but with careful consideration of the hazards involved, most of these cases can be handled in a reasonable fashion. Be consistent!

These storage schemes are provided for use and reference. Selection of how the chemicals will be stored must take the issues identified into account. Based on the particular chemicals being stored, select segregate storage to establish as safe a learning environment as possible.

Ward's Science chemical's are labeled with the 5 color-coded areas in mind. If you have older chemicals in your inventory that are still suitable for use, Ward's Science can provide you or your Chemical Hygiene Officer with materials to color code these chemicals and streamline your chemical organization. . A Ward's Science Color-Coded Storage of Chemicals poster is presented at the end of *Section V – Chemical Labeling*.

Figure 1 Ward's Science Color-Coded Chemical Storage

Suggested Practices of Chemical Storage

- Store chemicals according to manufacturers' recommendations.
- Chemicals should be dated when received and when opened. Date and store new chemicals in a manner that enables the older chemicals to be used first. If the chemical is one that degrades in quality or becomes unsafe after prolonged storage, the shelf-life expiration date should also be noted.
- If possible, keep certain items in the original shipping package, e.g., acids and bases in special and expensive foam cubes if they are supplied that way.
- Post an index on the door of each storage area showing the location and storage pattern for all chemicals. Also post emergency telephone numbers in the chemical stores area.
- Shelving should be no deeper than 12-14" and should be secured to walls or floor to prevent tipping. Shelves should be equipped with lips to prevent products from rolling off. Consider using Plasteel instead of wood for shelf construction.
- Do not store flammable materials outside of an approved flammables storage cabinet. Flammables kept outside a cabinet should only be in an approved safety can.
- The storage area and cabinets should be labeled to identify the hazardous nature of the products stored within.
- Chemicals must be stored at an appropriate temperature and humidity level. Chemicals should not be stored near heat sources, such as steam piping or laboratory ovens. Chemicals should *never* be stored in direct sunlight.
- Do not store hazardous chemicals above eye level. Store large bottles on bottom shelves
- Chemicals should not be stored on the floor except in approved shipping containers.
- Acids more than a 6 M concentration should be stored in an acid cabinet
- Water-reactive products (sodium metal, potassium metal, etc.) should be stored under dry oil and further isolated using a strong, sealable outer container such as a can.
- Glass containers should not touch each other on the shelves.
- Secondary containers or trays should be used for chemical storage whenever possible to minimize the flow of material should a spill occur.
- Chemicals should not be stored on benchtops. Only the amounts for immediate use should be kept on benchtops.
- Keep sources of ignition away from the chemical stores area.
- Do not store chemicals in a fume hood.
- Neutralizing chemicals, such as a spill kit, dry sand, vermiculite, and other spill control materials, should be readily available.
- Tri-Class ABC fire extinguishers should be in the chemical stores area.
- Only authorized personnel shall have access to the chemical storage area.
- Complete an annual safety review procedure for your chemical stores area.

Refrigerated Storage

Flammable materials must *never* be stored in ordinary domestic-type refrigerators. Only explosion-proof or flammable material refrigerators should be used for storage of chemicals. Ignition sources available inside a domestic refrigerator storage compartment and the compressor and its circuits are typically located at the bottom of the unit, where chemical vapors can easily accumulate.

A prep room "explosion-proof" or "flammables rated" refrigerator used for storage for flammable liquids can be purchased from Ward's Science distributors. Under no circumstances should you attempt to perform modification on a domestic refrigerator yourself.

Only store chemicals with flashpoints higher than the temperature of the refrigerator.

- Do not store peroxide formers (i.e., ether) in a refrigerator.
- All containers stored within the refrigerator should be tightly capped to keep vapors from interacting with each other.
- Flasks with cork, rubber or glass stoppers should be avoided because of the potential for leaking.
- Food shall not be stored in a refrigerator used for chemical storage. The refrigerator shall be labeled "Food Must Not Be Stored in This Refrigerator" or equivalent.
- Inventory the materials in your refrigerator frequently.
- Defrost your refrigerator/freezer on a regular basis.

Secondary Containment

Secondary containment is used to provide protection in case a spill occurs to contain the spill in a secondary area. Secondary containment will reduce the risk of the hazards involved including chemical exposure, fire, explosion, etc.

Secondary containment is recommended at all times when chemicals are being transported from room to room.

Secondary containers:

- For a single container, must be sized to contain 110% of the single container's capacity.
- For multiple containers stored in the same secondary container: the secondary container must be able to contain 150% of the largest container or 10% of the aggregate quantity stored, whichever is greater .
- Must be capable of holding any spilled material until the spill can be cleaned up.
- The secondary container must be compatible with the hazardous material.

Chemical Waste Storage

The following is provided to assist in defining safe practices for the temporary storage of hazardous wastes. For detailed information on waste disposal please refer to *Section XIV – Chemical Disposal* .

- Hazardous waste should be stored away from the general non-hazardous waste.
- Different types of waste should be stored separately.
- Do not store non-compatible wastes next to one another.
- Hazardous waste should be stored in sealed containers and kept away from direct sunlight.
- Properly label storage waste containers
- Ensure the compatibility of waste containers with their intended contents. For example metal drums should not be used for acid wastes.
- Leave enough space in liquid waste drums to allow for expansion of the contents.
- Keep storage of wastes to a minimum. Dispose of waste on a regular basis to prevent waste build-up.

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