FLORIDA

School Chemical Cleanout Manual

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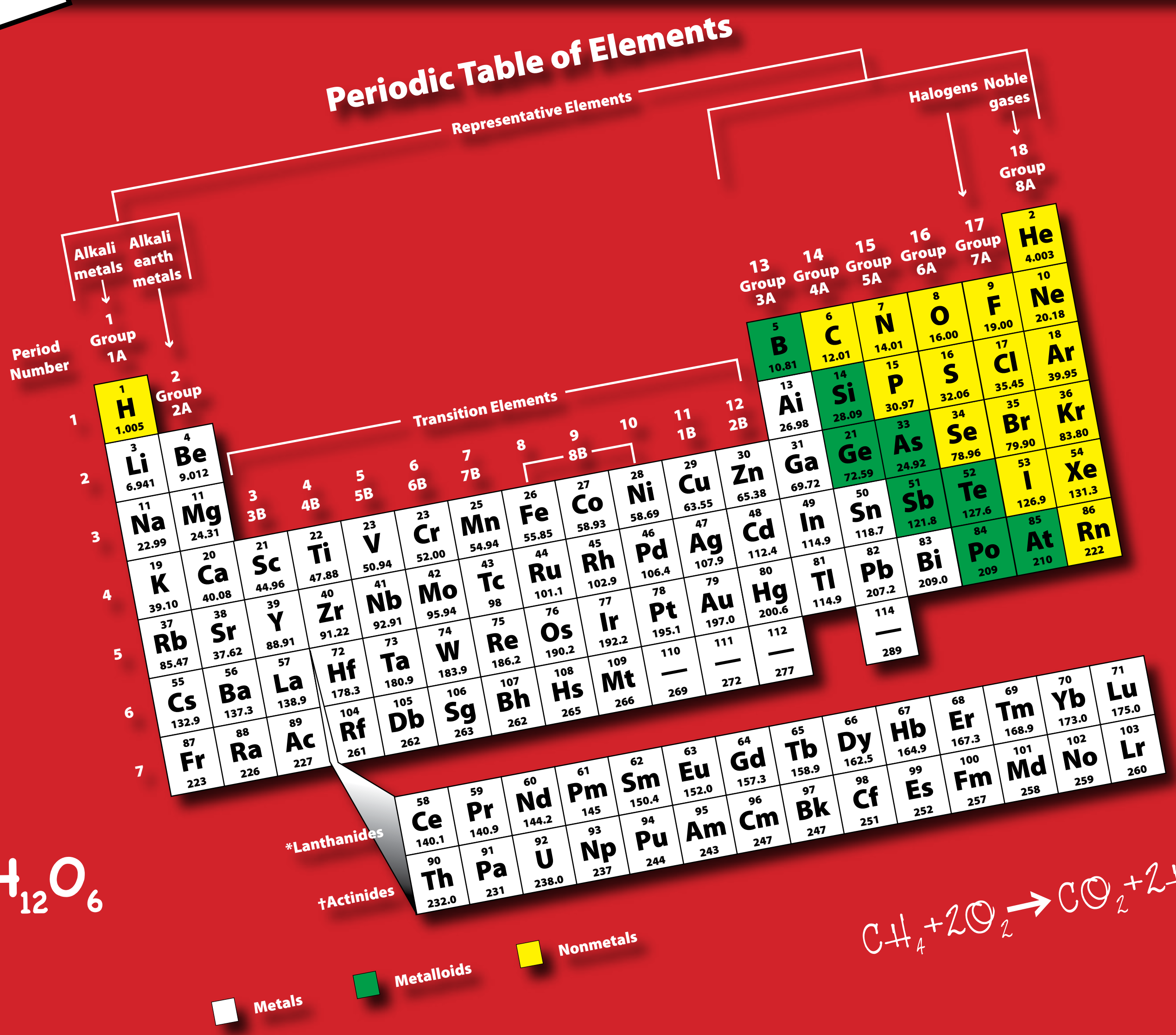

$C_6H_{12}O_6$

$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

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Division of Waste Management
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Contents

Chapter 1: Introduction

1.1 Hazardous Materials in Schools

Hazardous materials can be found in many programs and areas within a school. These include art classrooms; science stockrooms and laboratories; auto, metal and wood shop classes; photography darkrooms; printing rooms; and grounds maintenance and custodial departments. Mercury thermometers or mercury blood pressure sphygmomanometers may be present in nurses' offices.

Often, these chemicals are not well managed: they are stored in the wrong place, in decrepit containers, and alongside other chemicals with which they are incompatible. Because staff often does not know what to do with old chemicals that are no longer used, the chemicals are kept, sometimes for decades, after which time many chemicals deteriorate, become contaminated or even unstable.

Incidents involving hazardous chemicals are a common cause of problems in schools and have resulted in serious injury, property damage and schools being shut down for weeks to be decontaminated.

Improving chemical management procedures will simplify the task of dealing with excess chemicals and arranging for their disposal. Practicing waste minimization and pollution prevention in schools sets an example for students and helps them develop a responsible attitude toward the environment. Incorporating sound chemical management and handling techniques into the curriculum will teach students skills that will contribute to their lifelong health and safety.

This manual will provide information to help schools establish and maintain Best Management Practices for the selection, purchasing, storage, safe handling and proper disposal of chemicals used in schools. This will provide a safe environment for students, teachers, and staff, while simultaneously ensuring compliance with applicable regulations.

1.2 Chemical Management Responsibilities

It is the responsibility of schools to ensure that chemicals and their wastes are safely and legally handled and disposed of properly. It is recommended that schools or districts form safety committees. These committees should meet periodically to ensure that chemicals and products are being handled properly, and that the requirements of all applicable federal, state and local environmental, health and safety regulations are being met. Safety committees can assist in maintaining school inventories, providing hazardous materials training, alerting the local fire department of chemicals being stored and used in the school, and maintaining the necessary records. A safety committee should include someone from the school district's risk management program, the school's chemical hygiene officer (see below) and a representative from building maintenance.

The Occupational Safety and Health Administration (OSHA) requires all laboratories, including school science laboratories, to implement a written Chemical Hygiene Plan. Topics that should be addressed in a science lab's chemical hygiene plan include rules and procedures about the following:

1. **Chemical procurement, distribution and storage.**
2. **Housekeeping, maintenance, and inspections of the stockroom and laboratories.**
3. **Personal protective apparel and equipment for teachers and staff.**
4. **Warning signs and container labels to identify hazards.**
5. **Spill response procedures.**
6. **Waste disposal.**
7. **Training of staff in the plan.**

OSHA requires that a Chemical Hygiene Officer be appointed to implement the plan. The Chemical Hygiene Officer may be a staff member from within the school or school district, or a person or company under contract. The Chemical Hygiene Officer should be a member of the safety committee for each school with a laboratory that falls under the officer's oversight.

1.3 Creating a Chemical Management Plan

Schools need to safely manage chemicals in an organized manner. Many schools have accumulated chemicals that they no longer need, and some of these chemicals should be disposed of as hazardous waste. By law, regulated hazardous wastes must be properly handled from their initial generation to their final point of disposal under a concept commonly known as "cradle to grave" responsibility. Accountability should be assigned to ensure that the plan continues to be followed.

There are several steps to creating a school chemical management plan:

1 **Conduct a chemical inventory.**
2. **Properly dispose of unwanted chemicals.**
3. **Develop strategies to reduce the use of hazardous chemicals.**
4. **Acquire information about the chemicals in use.**
5. **Store and handle chemicals safely.**
6. **Develop a spill-response plan.**
7. **Institute a centralized purchasing policy to monitor and control the acquisition of chemicals.**

Chapter 2: Assessing the Situation
Conducting a Chemical Inventory

2.1 Purpose of the Inventory

Many chemicals found in middle and high schools pose risks to staff and students because of their hazardous characteristics (flammability, corrosivity, reactivity or toxicity) and because their containers and contents have deteriorated over time. A complete chemical inventory will identify these chemicals. Up to date chemical inventories should be available in every school department prior to the ordering of any new chemicals.

By conducting chemical inventories, schools can identify unneeded, out-of-date chemicals and arrange to have these chemicals disposed of before they cause problems. Accurate inventories will also help prevent the purchasing of chemicals already in stock.

2.2 Guidelines for Conducting a Chemical Inventory

Conducting a chemical inventory may pose significant risks to the individuals taking the inventory; therefore, only those who have technical knowledge about the chemicals should be involved. Students should never participate in inventories! In some cases an inventory may take many hours to complete—it is important not to underestimate the amount of time required to complete the inventory. Administrators may not be aware of the time commitment and the importance of an accurate inventory; therefore, it is very important to inform them. If you are new to the school and/or a recent inventory has not been conducted, you need to be especially cautious. Serious injury can result from touching or moving chemicals that have become shock sensitive or pressurized. If any chemical container is unmarked, bulging, leaking, rusted, cracked, or has a degraded top; or contains a liquid above a solid, or crystals in a liquid; it should not be moved unless you are sure that it is safe to do so. It is best to be cautious!

2.3 Suggested Inventory Procedure

1) Allow ample time to conduct the inventory.
2) Have a plan to deal with potential explosives if they are found and verify that everyone listed in the plan is familiar with their role. Contact your county's Sheriff's Office for information about access to the services of a "bomb squad" if needed. Notify your local sheriff and fire department that you will be doing an inventory, especially if this is the first inventory in several years.
3) Work in pairs, never alone. It is best if one team does the entire inventory.
4) Be sure the areas in which you are working have adequate lighting and ventilation.

5) Wear appropriate Personal Protective Equipment (PPE). This should include gloves, chemical splash goggles, a lab apron, and closed-toed shoes. Review the section on PPE before beginning the inventory.

6) Be sure that you have quick access to a phone and a recently tested eyewash and safety shower.

At a minimum, a chemical inventory should include the following information for each chemical or product:

- **Chemical or product name.**
- **Place where material is being stored (room, name, building).**
- **Program using the material and whether it is currently being used.**
- **Date of purchase (if unknown, write "Prior to" and the inventory date).**
- **Amount of material currently in school.**

7) Have a written response plan nearby in case of a spill or accident and verify that all participants have read it in advance.

One person should act as the recorder and the other person should read the names of the chemicals. The reader should be sure to pronounce the names correctly and confirm that they have been recorded accurately.

The inventory can be used to generate a disposal list and to decide which chemicals to retain. Hazardous waste removal companies require very specific information, so it is important to include sufficient information about the chemical to avoid unexpected price changes. For example, anhydrous aluminum chloride is much more expensive to dispose of than hydrated aluminum chloride. A disposal list should include the proper chemical name, the size of the container and the approximate amount present.

Chapter 3: Acquiring Information About Chemicals

3.1 Labels

Modern container labels contain a great deal of information about their contents, including ingredients, directions for use, health concerns, storage and disposal instructions, and the manufacturer's name, address and phone number. The labels of very old chemicals offer far less information. Poorly managed chemicals may have missing labels or labels that have deteriorated. Deteriorated labels should be replaced with new labels with the chemical's name, primary hazards, and date of purchase or inventory date.

3.2 Material Safety Data Sheets

When chemicals and chemical products are sold, the manufacturer must supply Material Safety Data Sheets (MSDSs) to the buyer upon request. Many MSDSs are also readily available on the Internet. (Search the name of the chemical or product, plus MSDS, plus manufacturer's name.) MSDSs contain information about the chemical and physical data such as flammability, reactivity and incompatibilities; health effects; spill procedures and government regulations for its transportation and proper disposal. Schools are required to keep an MSDS for every hazardous chemical on their premises. Typically this is done by keeping a file containing a copy of each MSDS in an area near where the chemicals are being stored so that they are easily available to employees who could come in contact with the chemicals. Check to see if your local fire department needs copies of school chemical inventories and MSDSs, which may be found at:

www.hazard.com/msds

3.3 Books

Chemical dictionaries provide a quick reference to basic information. An especially valuable resource is *The Merck Index: An Encyclopedia of Chemicals, Drugs, & Biologicals*, Merck & Co., Inc., Whitehouse Station, New Jersey.

3.4 Analysis

Unlabeled chemicals can sometimes be identified using simple tests. Some examples are in the manual Identification of Unknowns at Household Hazardous Waste Centers, which is on the Resource CD. For those unknowns beyond the scope of that manual, or those that are suspected of being highly dangerous, it will be necessary to have them identified by a commercial laboratory. Look in your local Yellow Pages under "Laboratories, Analytical" and ask if they can provide this service.

Chapter 4: High Risk Chemicals

4.1 Excessive Risk Chemicals: Risk Exceeds Educational Utility

The list of Chemicals with Severe Hazards in Appendix 1 includes those that most experts believe present such an unacceptable probability of causing problems that ***they should not be present in secondary schools.*** Some school districts require that teachers wishing to use any chemical on the list ask permission and provide justification to do so.

None of these chemicals should ever be stored or handled in elementary, middle or junior high schools, or in district facility maintenance shops. Only persons with knowledge of chemistry should manage them. Teachers wanting to use any of these chemicals must be willing to provide the high level of care and monitoring that their safe use requires.

In some advanced curricula in high schools, either a very small amount or a highly diluted solution of one of these compounds may be desired for a unique experiment. Purchase either the smallest amount possible or a pre-diluted solution. Consider an alternate experiment that does not require the use of one of these high-hazard compounds.

The following sections provide information about high-risk chemicals commonly found in schools.

4.2 Mercury

Elemental mercury is quite volatile, especially when heated, and the vapors are very toxic. Incidents in schools throughout the United States have illustrated that costs resulting from a mercury spill can be in the tens of thousands of dollars. Such spills pose risks to children in particular and cause anxiety in the students, teachers, and parents. There are suitable alternatives that make the continuing use of mercury in the classroom, as well as the school nurses' office, an unnecessary risk to public health and the environment. Many schools have banned the use of mercury.

Elemental mercury, mercury compounds and mercury-containing devices may be found in many different areas throughout a school. In the past, elemental mercury has been a common chemical in school science laboratory experiments. The following table lists examples of areas within a school where elemental mercury, mercury compounds, and mercury-containing devices can be located.

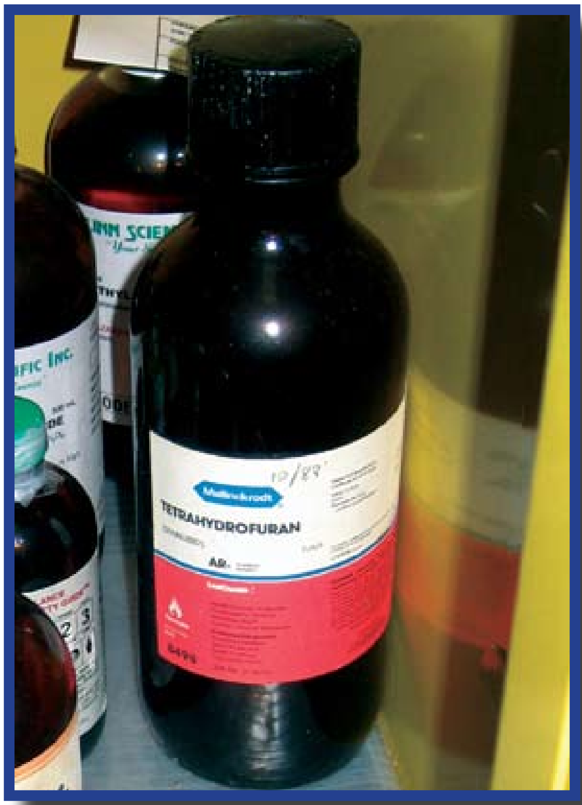
Science Labs	Maintenance	Nurse's Office
Elemental Mercury	Fluorescent Lamps	Fever Thermometers
Mercury Thermometers	Mercury Thermostats	Blood Pressure Devices
Mercury Barometers	Mercury Vapor Lamps	
Mercury Compounds	Mercury Light Switches	Home Economics
• Mercury Oxide	Mercury Switches & Relays	Cooking Thermometers
• Mercury Chloride		
• Mercury Nitrate	Art Rooms	Other
• Mercury Sulfate	Paint (True Vermilion)	Mercury Batteries

4.3 Peroxidizable Solvents and Metals

Most organic solvents are flammable, some are toxic, and a few have the additional risk of potentially forming unstable peroxides as they age and are exposed to air and light. There is a list of peroxide-forming chemicals in the Appendix 2. Isopropyl ether is the most dangerous, but ethyl ether is the one most commonly found in school laboratories and has been the cause of many accidents. These peroxides are extremely unstable crystals that tend to form under the cap of the container. The friction from opening the container or the shock from being dropped can cause them to detonate. Peroxidizable solvents must be carefully monitored to prevent and detect the formation of explosive peroxides.

Record the date of arrival when a peroxide former is received. Record the date it is first opened. The solvent should be used within three months of opening. Check for the presence of peroxides before use, especially if the chemical will be subjected to heat or evaporation. This is easily done by adding an equal amount of a 10% solution of potassium iodide to a few milliliters of the solvent in a test tube. Shake gently and observe the aqueous layer. The development of a brownish color indicates the presence of peroxides, and the solvent must not be used and must be disposed of as soon as possible.

The alkali metals, especially potassium, also form unstable peroxides as they are exposed to air. The alkali metals are also extremely water reactive and must be stored under oil or kerosene to prevent contact with water. Even when stored correctly, over time enough air diffuses through the oil to allow peroxides, which are yellowish in color, to form. Alkali metals must be examined frequently to ensure that the oil or kerosene has not spilled, leaked or evaporated, and that peroxides have not developed.



Tetrahydrofuran dated October 1988

Cyclohexene dated 2001

4.4 Oxidizers

An oxidizer is any chemical that accepts electrons in a reaction; not all oxidizers contain oxygen. Oxidizers can be hazardous if they are capable of supporting combustion even in the absence of air. They vary greatly in strength-- 3% hydrogen peroxide is a very mild oxidizer and harmless, but 70% perchloric acid can oxidize reducing agents with explosive force. Oxidizers common to schools are nitrites, nitrates (including nitric acid), chromates, dichromates, peroxides, some dioxides, superoxides, hypochlorites, chlorites, chlorates, perchlorates (including perchloric acid) permanganates and the elemental halogens. Strong oxidizers must not be stored with combustible materials, including wooden shelves. Nitric and perchloric acids cannot be stored with organic acids.

4.5 Self-Oxidizers

Certain organic chemicals, because they contain both fuel and reactive oxygen in the same molecule, are capable of self-combustion, sometimes with explosive force. Examples are organic peroxides, such as benzoyl peroxide, and polynitrated organics, such as trinitrophenol (picric acid). Ten percent or more of water is added to these compounds before they are shipped to reduce their hazard. They must be carefully monitored during storage to ensure that they do not dry out; if they do, they present a severe risk. Never move or open a container of one of these compounds if you are unsure of its state of hydration. Dehydrated self-oxidizers require the expertise of "bomb squad" personnel.

Ether

4.6 Highly Toxic Chemicals

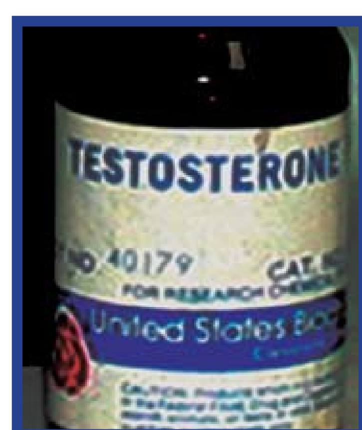
Schools should avoid keeping any highly toxic chemicals that can be fatal at low doses. Some examples are cyanides, arsenic compounds, carbon disulfide, nicotine, osmium tetraoxide, sodium azide, bromine and hydrofluoric acid.

If any highly toxic chemical is to be retained, everyone working with it must be very familiar with its characteristics, techniques to prevent exposure and first aid procedures in the event of an exposure. If cyanide salts are present, a first aid kit specific for cyanide poisoning must be on site as well, as cyanide poisoning is almost immediately fatal.

Many highly toxic chemicals are "P-listed" under hazardous waste regulations ***(See 40 CFR 261.33)***, which means that a facility that disposes of more than one kilogram in a calendar month is subject to the full regulatory requirements of a Large Quantity Generator of hazardous waste. This higher level of regulation includes special notification to the Environmental Protection Agency (EPA), biennial hazardous waste reporting and to implement special emergency management procedures and training.

4.7 Chemicals Regulated by the Drug Enforcement Administration

"Controlled substances" are narcotics and other chemicals with the potential of being abused, mainly for recreation or performance enhancement. There are five "schedules" of controlled substances based on their relative hazards. A list of controlled substances is on the Resource CD. Controlled substances are strictly regulated by the Drug Enforcement Administration (DEA). Compliance with these regulations is very difficult, and it is easy to get into trouble. Some examples of controlled substances that have been found in schools are chloral hydrate, testosterone, phenobarbital, morphine, and amyl nitrite (an essential component of cyanide-poisoning first aid kits).



4.8 Radioactive Chemicals

Radioactive chemicals are regulated by the Florida Department of Health, Bureau of Radiation Control.

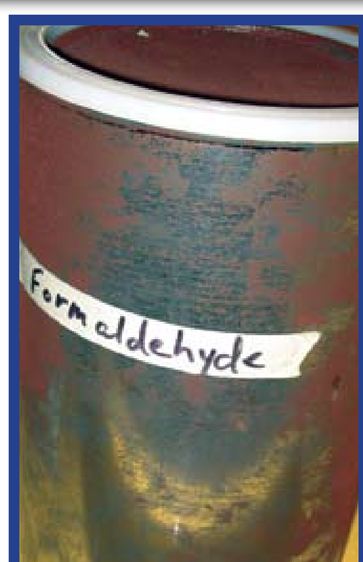
These regulations require meticulous record keeping and monitoring. It is extremely expensive to dispose of radioactive chemicals. Uranium and thorium salts, which are occasionally found in school science laboratories, are exempt from most Department of Health regulations.

4.9 Formaldehyde

Formaldehyde is a known carcinogen, a severe respiratory irritant, and a potent sensitizer. Formalin is an aqueous solution of formaldehyde gas with methanol added to prevent polymerization. Formalin was widely used to preserve tissue samples, and older biological specimens very likely contain it. Great care must be taken to minimize exposure to formaldehyde when handling specimens preserved with formalin. Although supply companies have reduced the amount of formalin used in the fixation process, it is still often present in specimen samples. Some supply companies offer formalin-free specimens.

! *Great care must be taken to minimize exposure to formaldehyde when handling specimens preserved with formalin.*

H_2CO



Chapter 5: Minimizing the Use of Hazardous Chemicals

5.1 General Strategies for Reducing the Use of Chemicals in Schools

Many problems associated with school chemicals can be mitigated by instituting good chemical purchasing practices. A centralized purchasing policy helps to control the volume of chemicals in a school, reduce the acquisition of hazardous chemicals and eliminate duplicate orders. Centralization can be achieved by having one person or one department responsible for maintaining the school's chemical inventory and ordering. It is recommended that the district be involved in this process to look for economies of scale when several schools are purchasing similar products or chemicals. Some school districts have developed lists of chemicals that should not be used at their schools due to the chemicals' toxic or reactive properties. All orders should be checked against this list prior to purchase.

The following considerations will help in deciding if a chemical needs to be purchased:

1. **Check with other departments and schools to see if the chemical is already in stock and available. School districts may be able to post chemicals for exchange and reuse on the school districts intranet website.**
2. **Consider substituting a less toxic/hazardous form of the product if available. For example, high quality spirit or digital thermometers are as accurate as mercury thermometers without the associated toxic releases when broken.**
3. **Purchase only the amount needed. When the cost of disposing of excess chemicals is factored in, the economy size may not be the most economical choice.**
4. **Determine if there are any special handling or storage requirements for the chemical and, if so, if these requirements can be met. Consider also whether staff has the training and supplies to respond to a spill of the material.**
5. **Consider whether the chemical or product, when discarded, will be a regulated hazardous waste requiring special disposal or a non-hazardous waste that can be disposed of in the trash or down the drain. If it will be a regulated hazardous waste, include the cost of disposal when evaluating the costs of using the material.**
6. **Confirm that the school's ventilation system is adequate for using the product safely. Some chemicals should be handled only in a functioning fume hood. (Opening a window does not constitute adequate ventilation.)**

5.2 Best Management Practices for Science Laboratories

The greatest variety of chemicals are kept school science stockrooms, although generally in relatively small amounts. Because some of these chemicals are highly dangerous, most accidents involving chemicals at school have occurred in the science department. Therefore, the science curriculum should be scrutinized to seek ways to minimize the storage and use of high-hazard chemicals.

The following strategies should be considered:

- **Select analytical methods that do not require hazardous chemicals.**
- **Substitute hazardous chemicals with less toxic alternatives.**
- **Use reduced-scale techniques when available to reduce analytical wastes.**
- **Ask if your suppliers offer chemicals in small volumes, and buy them in small lots. This can reduce waste and leftover materials in case procedures are changed, expiration dates pass or spills occur. Vendors are now offering laboratory chemicals in units less than 100 grams and volumes below 100 milliliters. Look for the smallest container size or a five-year supply, whichever is more economical.**
- **Date containers when they arrive so you can see how quickly they are used. Bar coding systems are now available to track inventory.**
- **Consolidate or coordinate purchasing authority to reduce duplicate purchases of chemicals and improve inventory tracking.**

5.2.1 Reduced-Scale Chemistry

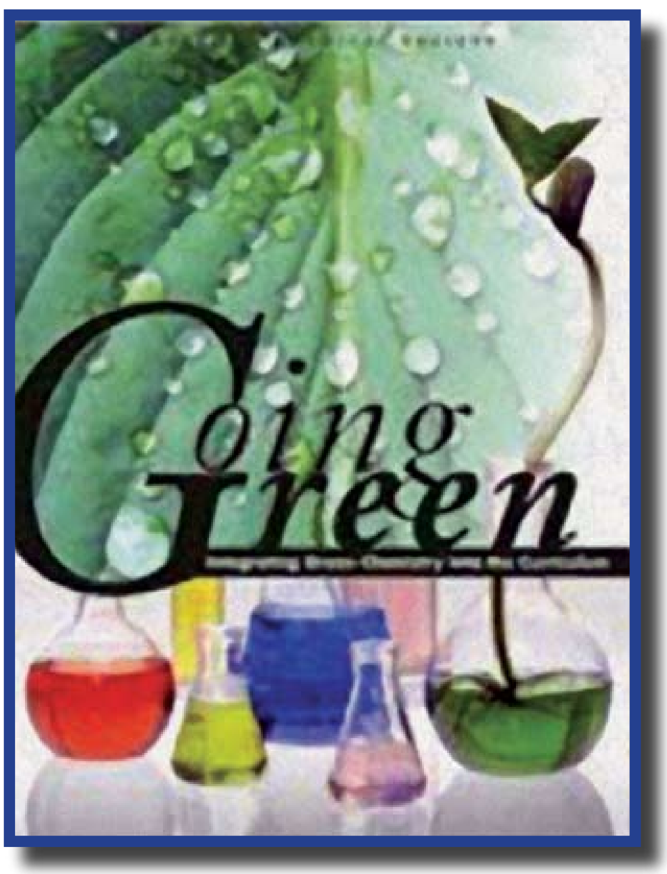
Reduced-scale chemistry miniaturizes traditional laboratory experiments by using smaller chemical quantities, miniature or modified lab ware, and modified processes to demonstrate common scientific concepts. Often chemical use is reduced to 1/100th or 1/1000th of traditional experiments. There are two types of reduced-scale chemistry: "small" and "micro." The terms are sometimes used interchangeably.

- **Small-scale chemistry** uses inexpensive plastic and polymer materials in place of glassware, reuses single-use equipment and uses solutions of very low concentration. It is commonly used in secondary school classrooms.
- **Microscale chemistry** uses very small glassware and minute amounts of chemicals. Microscale chemistry is more common at university level labs, although the methods can be used by secondary schools. Converting to microscale chemistry involves an initial investment in specialized glassware and balances that can weigh to the nearest 0.1 mg.

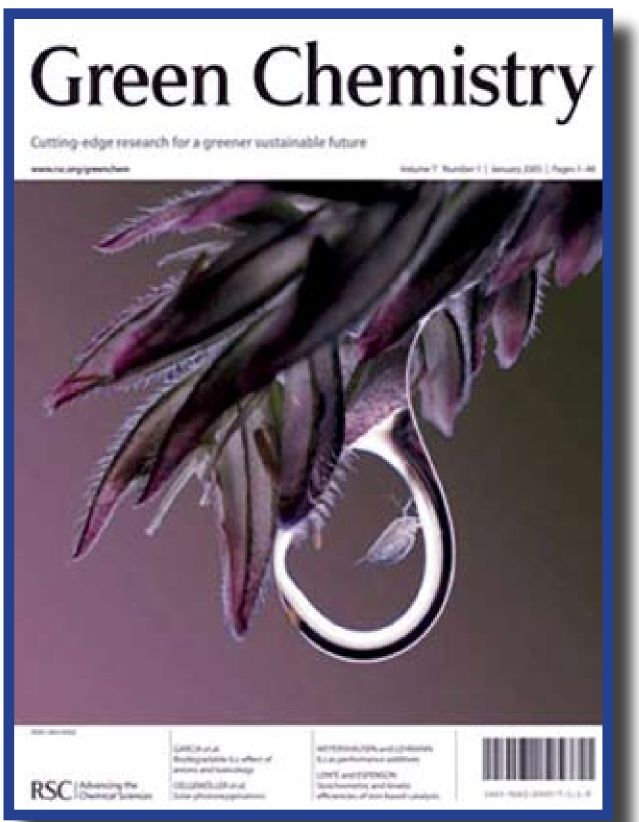
Not all experiments lend themselves to substantial reduction in scale. For those experiments for which you wish to use conventional glassware, try decreasing experimental quantities by a third or half. A 50 percent reduction in quantities can usually be achieved with conventional glassware with no loss in experimental results. Such scale reductions may require a few trial runs to ensure desired experimental results.

Practicing reduced-scale chemistry provides many benefits:

- **Reduces preparation time.** A single teacher can prepare for class in a matter of minutes.
- **Reduces cleanup time.** Many experiments use single drops on plastic sheets or in plastic well plates that can easily be cleaned with a paper towel.
- **Allows student to repeat experiments.** Since reactions are taking place at such a small scale, there is often time to repeat the experiment. This emphasizes the scientific necessity of basing conclusions on the average of several observations, and offers an opportunity to teach students about the statistical evaluation of data.
- **Improves the efficiency of lecture and laboratory time.** The shorter length experiments allow the teacher to lecture and perform laboratory activities for the concepts covered in the same class period.
- **Allows for more experiments and more variety in experiments.** Experiments become time- and cost-effective when performed on a small scale.
- **Lowers cost of lab ware.** Most small-scale lab ware is very inexpensive and hard-to-break plastic. Microscale kits can be costly initially, but can be used for many years. (Note: microscale glassware tends to be stolen, just because it is "cute" miniaturized versions of conventional glassware.)
- **Reduces hazards.** Small quantities of chemicals mean less chance for spills, less waste and smaller exposures in case of accidental contact with skin or eyes.
- **Improves indoor air quality.**



- **Reduces storage area needed.** Both the chemicals and lab ware used in reduced-scale chemistry take up a much smaller amount of space as compared to traditional experiments.
- **Saves money.** The economic benefits of reduced-scale chemistry are significant. The cost of running a small-scale lab for chemistry students at Colorado State University was 25 times less than a traditional scale lab.
- **Teaches modern lab techniques.** Reduced-scale chemistry requires students to be somewhat more precise while performing experiments, a very important skill in industrial and university-level laboratories. Most industrial labs have adopted reduced-scale chemistry.



- **Allows for individual experiments.** Macroscale laboratories are often so costly as to prohibit individual lab work. While working in a group has its benefits, individual experiments give everyone an opportunity to develop good lab techniques. This also can help the instructor determine who might need additional assistance for each concept covered.

The National Microscale Chemistry Center was established to promote the use of microscale chemistry as a means of eliminating toxic waste at the source. Learn more about this topic by visiting this website:

www.microscale.org.

The National Small-Scale Chemistry Center provides resources to scale down chemical reagents to volumes and masses 1,000 times smaller than those used in traditional labs by using inexpensive plastic and polymer materials. Learn more about this topic by visiting this website:

www.smallscalechemistry.colostate.edu.

5.2.2 Chemistry of the Ordinary

Often called "kitchen chemistry," this strategy uses reactions involving common household chemicals to demonstrate various concepts. The benefits of this technique include the following:

- Materials used are easily available and usually inexpensive.
- Household chemicals are usually less hazardous; therefore, they are safer to use and their disposal easier. There are, of course, some exceptions to this.
- Demonstrates to students that chemistry not an arcane, obscure subject; it relevant to their everyday lives.

Kitchen Chemicals

Some examples of experiments using ordinary household chemicals:

- Kinetics: effect of concentration on reaction rates using vinegar and baking soda.
- Displacement: removing tarnish from silver items using aluminum foil and baking soda.
- Covalent and ionic bonds: using table salt, vinegar, rubbing alcohol, and bleach.
- Triple point/phase diagram of CO_2: dry ice.

King County in Washington State has developed a program called Rehab the Lab to help local schools reduce the use of hazardous chemicals. Lesson plans for experiments using less hazardous chemicals can be downloaded at no cost from their website:

www.govlink.org/hazwaste/schoolyouth/rehab/labs.htm

5.2.3 Commercially Prepared Kits for Experiments

Some vendors offer experiment kits that contain pre-weighed reagents and prepared solutions in amounts suitable for a class of 25-30 students. These kits offer several advantages:

- Preparation time for setting up the experiment is greatly reduced.
- The amount of chemicals used is small and solutions are dilute, reducing risk of exposure.
- Weights and concentrations are accurate, helping to ensure a successful experiment.
- The kit includes instructions, explanations, worksheets, and report forms.
- There is very little waste to dispose of.

But there are some disadvantages, too:

- Students get less practice in weighing chemicals and preparing solutions accurately.
- The kits are more expensive than self-prepared experiments.

Chapter 6: Managing Chemicals in Schools

6.1 General Strategies

The following suggestions pertain to all departments that use chemicals in their programs:

- **Minimize the number of sites where chemicals are stored in the school. It is very difficult to keep track of chemicals if they are scattered throughout the facility. For example, store all laboratory chemicals in one stockroom, all chemical-based art supplies in one storage area, and all maintenance products in another. These storage areas should be locked and access to them should be limited.**

- **Ensure that all school staff routinely working with hazardous chemicals receives proper training in all phases of chemical management, including safe storage, proper use, potential hazards and proper methods of disposal. This is required under OSHA.**

- **Periodically inspect stored chemicals for signs of leakage, rusting and peeled labels, and expiration dates. Degraded labels should be immediately replaced to prevent unknowns.**

- **Maintain MSDS files for all chemicals and chemical products in the school. These files should be readily accessible to anyone who uses the chemical or product. Keep the file near where the chemicals are stored and keep another copy in the main office.**

- **Do not accept samples or donations of chemicals that conflict with the school's purchasing and disposal policies. Disposing of hazardous "gifts" can be very expensive. Often chemical donations turn out to be unneeded or degraded and unusable.**

- **Develop a written chemical spill plan that includes information on proper response to spills of all types of chemicals in storage or use at the school. This plan should include instructions on cleaning up small spills, protocol in the case of a large or dangerous spill, and notification requirements in the case of a reportable spill.**

- **Purchase or prepare chemical spill kits appropriate to the types of chemicals and products in use or storage.**

6.2 Standards for Chemical Storage Rooms

Any area where chemicals are stored should satisfy the following requirements:

- The room has adequate ventilation separate from the general ventilation system.
- An inventory of the chemicals present is maintained in each room where chemicals are stored.
- Hazardous material storage cabinets are anchored to walls.
- Doors on storage cabinets are closed and latched.
- Class ABC fire extinguishers are kept near locations where chemicals are stored or used and employees are trained in their operation. If flammable metals are present, a Class D extinguisher is needed as well.
- Secondary containment tubs are provided for liquid chemicals stored on counters and near drains.
- Volatile chemicals are stored in well-ventilated areas that exhaust outside the building to maintain indoor air quality.

6.3 Storage Systems

Schools can have numerous toxic, corrosive, reactive and flammable materials in storage. If these are stored close together, there is a risk of contact if the containers fail due to deterioration or breakage. The resulting spills could cause a reaction or a release to the environment. The proper storage of chemicals will minimize this risk.

- Do not store chemicals by alphabetical order, but by the chemical's hazard classification. Incompatible chemicals can react with one another, resulting in the release of toxic gases, fires, or even explosions. There are several systems that have been developed by chemical manufacturers, and the chemicals they sell are color-coded to ensure correct storage. See Section 6.4 for an example.

- Flammable chemicals should be stored separately in a flammable storage cabinet and well away from any oxidizing chemicals.

- Do not store low flash point flammable liquids in ordinary refrigerators or freezers. Use only explosion-proof refrigerators or, if solvents must be chilled for an experiment, put them in ice the night before.

- Corrosives should be stored away from other chemicals in corrosion resistant containers and cabinets. Acids—such as laboratory acids, sulfuric acid-based drain openers, battery acid and acidic cleaners, must be kept separate from caustic chemicals—such as hydroxide-based drain openers and paint strippers, ammonia solutions and caustic cleaners.

- Oxidizing acids, such as nitric and perchloric, should not be stored with combustible organic acids.

- Whenever possible, order concentrated corrosives and flammable solvents in plastic-coated bottles to reduce the risk of bottle breakage. Small containers are preferable because in the event of breakage a smaller spill results. Use rubber or plastic bottle carriers or bottle jackets when transporting glass containers. Store breakable containers inside dishpans that will contain spills.

- Avoid storing chemicals in fume hoods, on bench tops or under sinks. They interfere with airflow, clutter work space and could potentially spill into drains.

- Do not store chemicals on the floor or above eye level.

6.4 Systematic Storage System for Laboratory Chemicals

For schools with large stockrooms, we suggest following the storage and handling guidelines found in Prudent Practices in the Laboratory: Handling and Disposal of Chemicals (National Academy Press, Washington, DC).

Many universities publish diagrams of recommended chemical storage system on their websites. Two chemical supply companies, J.T. Baker and Flinn Scientific, Inc., also have popular systems for chemical storage. All = incorporate the concept of "related and compatible storage groups" found in Prudent Practices.

These systems are based on a series of codes for functional classes of chemicals. Organic and inorganic chemicals are separated, with sub-groups further separated. The "related and functional storage groups" listed in Prudent Practices and the shelf storage codes often assigned to these groups are listed below. ("I" refers to inorganic compounds and "O" refers to organic compounds.)

Shelf Storage Codes	Related And Functional Storage Groups
I-1	Metals, hydrides
I-2	Halides, sulfates, sulfites, thiosulfates, phosphates, halogens
I-3	Amides, nitrates (except ammonium nitrate), nitrites, azides
I-4	Hydroxides, oxides, silicates, carbonates, carbon
I-5	Sulfides, selenides, phosphides, carbides, nitrides
I-6	Chlorates, perchlorates, chlorites, hypochlorites, peroxides
I-7	Arsenates, cyanides, cyanates
I-8	Borates, chromates, manganates, permanganates
I-9	Inorganic acids
I-10	Sulfur, phosphorus, arsenic, phosphorus pentoxide
O-1	Organic acids anhydrides, peracids
O-2	Alcohols, glycols, - amines, - amides, - imines, - imides
O-3	Hydrocarbons, esters, aldehydes
O-4	- Amines, - imines, pyridine
O-5	Ethers, ketones, ketenes, halogenated hydrocarbons, ethylene oxide
O-6	Epoxy compounds, isocyanates
O-7	Organic peroxides, hydroperoxides, azides
O-8	Sulfides, polysulfides, sulfoxides, nitriles
O-9	Phenols, cresols

For labs with restricted storage spaces, compatible storage can be provided by grouping chemicals with similar hazards together. These labs could use a simplified system like the one illustrated below:

Inorganic Shelves	Organic Shelves
I-1 & I-10 – Sulfur, Phosphorus, Arsenic, Metals, Hydrides (Store All Away From Water!)	O-1 – Dry And Dilute Organic Acids, Anhydrides, Peracids
I-2 – Halides, Sulfates, Sulfites, Thiosulfates, Phosphates, Halogens	O-5 & O-7 – Organic Peroxides, Azides
I-5 & I-7 – Sulfides, Selenides, Phosphides, Carbides, Nitrides, Arsenates, Cyanides	O-6 & O-8 – Epoxy Compounds, Isocyanates, Sulfides, Sulfoxides, Nitriles
I-4 – Dry Hydroxides, Oxides, Silicates, Carbonates	O-9 – Miscellaneous Organics: Powdered And Alcohol-free Stains And Indicators
I-3, I-6 & I-8 – Nitrates, Nitrites, Borates, Chromates, Manganates, Permanganates, Chlorates, Chlorites, Inorganic Peroxides	Flammable Storage Cabinet – Hydrocarbons, Ethers, Ketones, Amines, Halogenated Hydrocarbons, Aldehydes, Alcohols, Glycols, Phenol, Cresol, Combustible Organic Acids, Combustible Anhydrides
Corrosive Acid Storage Cabinet – Inorganic Acids. Nitric Acid Stored Separately In This Or Another Cabinet	Corrosive Base Storage Cabinet Or Cupboard– Concentrated Liquid Inorganic Hydroxides

Notes: Keep water-reactive metals away from aqueous solutions and alcohols.
• Use secondary containers to separate yellow and white phosphorus, which are stored under water, from water-reactive metals.

6.5 Safe Chemical Handling

Even hazardous chemicals can be safely handled with proper barriers to exposure in place, such as adequate ventilation and personal protective equipment. Before working with a chemical for the first time, read its MSDS. The following components of good chemical management pertain to all chemicals and chemical products, even non-hazardous ones:

- **Maintain an organized and uncluttered work area, which will help prevent spills and accidents.**
- **Keep containers closed when not in use so that contents cannot evaporate or escape from a tipped container.**
- **Return chemicals to their proper place after use, or at least before leaving the workstation at the end of the day.**
- **Label prepared solutions and mixtures with the name of the compound, primary hazards, date of preparation, and initials of preparer. Chemical symbols alone are insufficient identification.**
- **Regularly check expiration dates on chemicals. Dispose of them properly or use them promptly. Write the date received on each chemical container that arrives and the date opened on all containers of peroxidizable solvents.**
- **Once opened, peroxidizable solvents should be routinely checked for the presence of peroxides, and should be checked immediately before any procedure involving evaporation of the solvent.**

Chapter 7: Personal Protective Equipment (PPE)

7.1 Role of Personal Protective Equipment in Safe Use of Hazardous Chemicals.

The purpose of Personal Protective Equipment (PPE) is to provide a barrier between the hazard and the person working with the hazard. Anyone at risk of coming into contact with a hazardous material should wear appropriate PPE to prevent or minimize exposure. Many chemicals can be directly absorbed through intact skin, so it is very important to select effective PPE. Wearing unsuitable PPE is dangerous, because it gives you a false sense of security; you think that you are protected, but you are not.

7.2 Selecting Appropriate PPE

There are many types of PPE designed to protect against various hazards. PPE can be as simple as safety glasses, a rubber or plastic apron, and gloves, or as elaborate as a totally encapsulating "moon suit." Because wearing PPE can be uncomfortable and even stressful-- hampering communication, vision, and dexterity-- do not wear more PPE than necessary. Before working with a chemical or product, you should research its characteristics and hazards to help you select the PPE that will protect you. Much information can be found on labels, on MSDSs, in safety catalogs and on the Internet.

7.3 Eye Protection

Whenever there is even a remote chance of a chemical splashing into the eyes, eye protection should be worn. Even those chemicals that will not cause permanent damage can cause intense discomfort or momentary blindness. Simple safety glasses with side shields may be sufficient for most activities and should always be required in a laboratory setting. Goggles provide better protection but are less comfortable. (Comfort should be considered due to the temptation to remove uncomfortable PPE.) Fog-eliminating products are available to prevent condensation from obscuring the goggle wearer's vision. For high-risk procedures, a full-face shield offers the best protection.

7.4 Gloves

No single glove material can protect you against all chemicals (although the "Silver Shield" comes close). Be sure to select a glove material that will provide good protection against the chemicals you will be handling. If you will be handling multiple chemicals, you may have to change to a different glove or even wear two pairs together ("double gloving"). Safety supply catalogs can be a useful source of information about the relative efficacy of various glove materials. Be aware of "breakthrough times," the amount of time it takes a particular chemical to penetrate the glove material, thereby allowing an exposure to occur. Consider gloves to be disposable items and discard them once pertinent breakthrough times have been reached. Latex exam gloves are virtually transparent to chemicals and are a poor choice in almost all situations.

7.5 Protective Clothing

Anyone working with hazardous chemicals should wear long sleeves, long pants and closed-toed shoes, as well as an apron, lab coat or coverall. As is true for gloves, the material in protective clothing should provide a good barrier to the chemicals being used and have a reasonably long breakthrough time. Cloth lab coats should be laundered by a commercial laundry, not in your household washing machine, where they could contaminate other clothing. Consider using disposable chemical protective clothing.

7.6 Respirators

Do not use a respirator unless you have been trained to do so. The required training includes testing the fit and efficacy of the respirator. Air purifying respirators require different cartridges for different chemicals. These cartridges can become saturated so that they no longer function. A dust mask does not protect you from anything except dust—it is completely useless against gases, vapors and fumes. If you encounter a situation in which you think a respirator is necessary, call for someone who is trained in respirator use, such as the Fire Department.

7.7 Ventilation

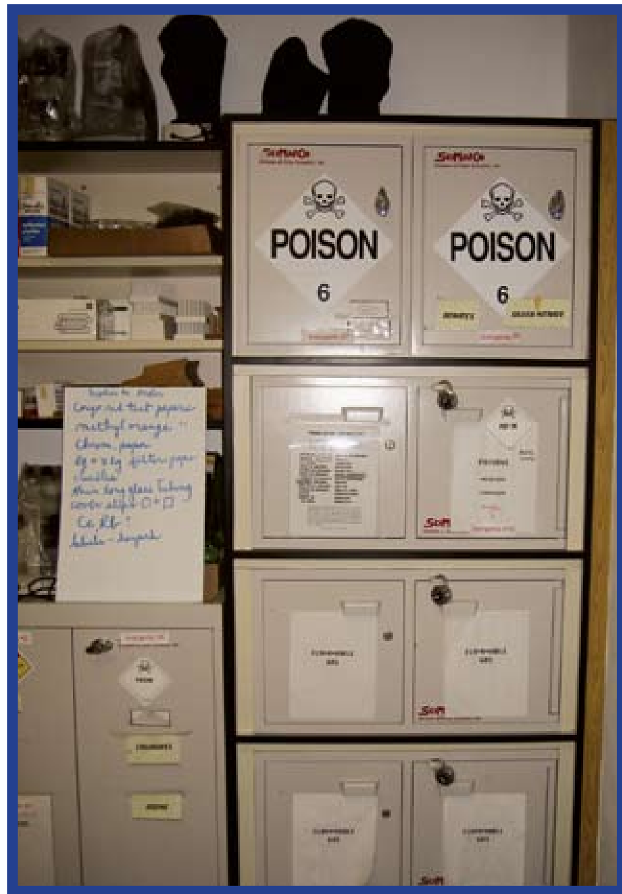
Good ventilation is a vital strategy for the safe handling of volatile hazardous chemicals. Chemistry stockrooms, in particular, should have adequate ventilation that is separate from the general ventilation, and preferably there should also be an emergency exhaust system in case of smoke, dust or a spill. If the ventilation in a chemical storage area is questionable, have it evaluated by an industrial hygienist.

Fume hoods are designed to provide a safe area for working with volatile hazardous chemicals. Do not use them as chemical storage cabinets! Clutter in a fume hood will restrict airflow and interfere with its function.

7.8 Administrative Controls

Chemical storerooms should be kept locked and only persons familiar with the hazards of the chemicals stored there should have access to the area. Extremely hazardous chemicals should be stored inside a locked cabinet in the locked storeroom.

Purchasing decisions can have a major effect in controlling chemical exposures by limiting the amount of hazardous chemicals bought, stored and used.



Chapter 8: Spill Management

8.1 Preventing spills

Most spills can be prevented by exercising these good chemical management practices:

- **Maintain a neat and organized work area.**
- **Store and transport chemicals in secondary containment trays or buckets.**
- **Keep containers closed, except when adding or removing contents.**
- **Avoid the purchase of chemicals in glass containers whenever possible.**
- **Buy chemicals in the smallest size that is practical. Smaller containers produce smaller spills.**
- **Check the condition of containers frequently.**

8.2 Cleaning Up Spills

Most chemical spills that occur in schools can be managed by employees who have been trained to do so. Areas where chemicals are stored or used should have appropriate spill kits immediately accessible. Commercial spill kits are available, but satisfactory homemade kits can be easily made using five-gallon buckets, absorbents, cleanup tools, and simple PPE. Vermiculite, oil dry, or heat-treated peat moss are suitable absorbents for organic solvent spills. Clumping kitty litter works well for aqueous spills and sodium bicarbonate will absorb and neutralize spills of both acids and bases. Cleanup tools (a dustpan and brush) should be made of plastic not metal, to prevent sparking. PPE should consist of splash goggles, neoprene gloves (a good all-purpose choice, but consult the chemical's MSDS first for recommendations about specific PPE), and a disposable apron or coverall. The cleanup tools and PPE should be in plastic bags inside the bucket.

8.2.1 First, assess the spill from a distance

- Do you know what it is? If the spilled material is unknown, you must assume it is hazardous and that you are neither equipped nor trained to handle it.
- How extensive is it? A large spill of even an innocuous substance may require that you seek assistance.
- What are the hazards of the spilled material? If the material is extremely toxic, reactive, flammable or volatile, outside assistance from a hazardous material response team will be necessary.
- If you are not confident that you can manage the spill on your own, seek assistance.

If you determine that the spill is minor enough that you can manage the clean up, follow these instructions:

8.2.2 Cleaning up small spills of neutral liquids

Don the PPE. If a drain is nearby, block it to prevent entry by the chemical. If the chemical is flammable, turn off all sources of ignition. If the chemical container is still leaking, place it inside a tub, or set it upright or rotate it so that the puncture from which it is leaking is uppermost. Make a dam around the spill with absorbent to contain the spill, and then cover the spill with the absorbent. Work from the outside edges of the spill to the center, taking care not to step in the spill. If stepping in the spill is unavoidable, be sure you are wearing protective footwear, that you do not spread the spill to uncontaminated areas and that you properly decontaminate or dispose of your footwear. Pick up the absorbent/chemical mixture using the dustpan and brush. Place this mixture inside a plastic bag. If broken glass is involved, pick up the pieces with tongs and place the glass inside the plastic bag. Wipe the tools with paper towels and place the towels inside the bag. Wash the area of the spill with detergent and water; absorb the wash water with paper towels that should also go into the bag. Wash the tools, goggles, and gloves with detergent. If the PPE you used is disposable, dispose of it in the plastic bag containing the spill.

8.2.3 Cleaning up small spills of liquid acids and bases

Cleanup technique is the same as for neutral spills, except that sodium bicarbonate is used as both an absorbent and a neutralizing agent. Sodium bicarbonate is a buffer; it will neutralize both acids and bases:

$$HCO_3^{-1} + OH^{-1} - H_2O + CO_3^{-2}.$$

A great deal of heat is generated when sodium bicarbonate comes in contact with concentrated acids. Add it slowly and use extreme care to avoid contact with skin. For acids and bases comprised of nontoxic ions, the resulting mixture can be disposed of in the trash once it is neutral. If toxic ions are involved, such as in chromic acid, the mixture must be disposed of as hazardous waste.

8.2.4 Cleaning up spills of solids

Don PPE. Carefully sweep up solids into the dustpan. Avoid stirring up chemical dust. Place the chemical inside plastic bags. Wash the spill area with detergent, wipe up with paper towels, and place them in the plastic bag. Wash tools and PPE with detergent. If they are disposable, place them inside the plastic bag with the other spill-related material.

8.2.5 Cleaning up mercury spills

If mercury is present in your school, you must be prepared to respond to a spill.

You can safely clean up spills of small amounts of mercury, such as is present in a thermometer. Any spill larger than this (more than one gram) should be cleaned up by a professional. Mercury spill kits can be purchased commercially or put together from existing materials, such as:

Clean Up with Existing Materials	
Powdered sulfur	Small paintbrush
Activated granular zinc	Flashlight
Rubber squeegee	Duct tape
Index card	Paper towels
Plastic dust pan	Shaving cream
Wide-mouthed plastic jar with air tight lid	Goggles
Eyedropper	Rubber gloves
Plastic bags with zipper seal	Trash bags

8.2.5.1 Cleaning up small mercury spills

- Check to make sure people's shoes and clothing have not been splashed with mercury before evacuating the spill area.
- Remove all metal jewelry from hands and wrists and don PPE.
- Turn off ventilating or air conditioning systems to prevent the spread of mercury vapors. If this is not possible, at least lower the temperature. Close interior doors and open exterior doors and windows.
- Contain the spill. Divert mercury away from drains and floor cracks.
- Use fans to ventilate the air to the outside.
- Never use a household vacuum cleaner or shop vacuum to clean up mercury! The mercury can volatilize and become airborne in the vacuum's exhaust.
- If there are any broken pieces of glass or sharp objects, pick them up with tongs. Place all broken objects on a paper towel. Fold the paper towel and place in a zip lock bag.
- Locate visible mercury beads. Use a squeegee or index card to slowly sweep mercury beads into the dustpan.
- Consolidate the mercury beads onto an index card and carefully transfer into a plastic jar. If necessary, use an eyedropper to suction off the mercury.
- Darken the spill area. Hold a flashlight at a low angle, close to the floor, and look for glistening beads of mercury that may be sticking to the surface or in small cracked areas of the surface. Note: mercury can move surprising distances on hard-flat surfaces, so be sure to inspect the entire room when "searching." Use an eyedropper to collect or draw up the mercury beads. Slowly and carefully squeeze mercury into the plastic jar. After you remove larger beads, put shaving cream on top of small paintbrush and gently "dot" the affected area to pick up smaller hard-to-see beads. Alternatively, use duct tape to collect smaller hard-to-see beads. Place the paintbrush or duct tape in a zip lock bag and secure.
- Sprinkle powdered sulfur or zinc on the spill area to bind any remaining mercury.
- Place all materials used with the cleanup, including gloves, in a trash bag. Place all mercury beads and objects into the trash bag. Secure the trash bag and label it "Mercury-Contaminated Spill Cleanup Material."
- Dispose of the waste as hazardous waste.

8.2.5.2 Cleaning up larger mercury spills:

The cleanup of larger mercury spills (more than one gram) should be done by a contractor who has the monitoring equipment to screen for mercury vapors. Consult your local environmental or health agency to inquire about contractors in your area. Spills greater than one pound (about two tablespoons) must be reported to the State Warning Point (1-800-320-0519).

Remember that any materials used to clean up a chemical regulated as a hazardous waste must also be disposed of as a hazardous waste.

8.3 Spills Requiring Outside Assistance

Large spills, spills that may escape to the environment, or any spill of an extremely hazardous chemical will require the assistance of a specially trained First Responder Team. These instructions should be followed:

- **If necessary, evacuate to an upwind location, taking class roster. Teachers should take attendance after evacuation. For a major spill or a spill of an extremely dangerous chemical, call 911. If the type and/or location of the hazardous material is known, report that information to 911**
- **Notify building administrator/office.**
- **Seal off area of leak/spill. Close doors.**
- **Upon arrival, the emergency officer in charge will determine additional shelter-in-place or evacuation actions.**
- **Shut off heating, cooling, and ventilation systems in contaminated area to reduce the spread of contamination.**

- **Building administrator should notify superintendent.**
- **Notify parents/guardians if students are evacuated, according to district policy and/or guidance.**
- **Resume normal operations when emergency officials approve.**

Chapter 9: Chemical Disposal

9.1 Regulated Hazardous Waste

The disposal of certain chemicals is regulated by federal law: the Resource Conservation and Recovery Act of 1976. This law is frequently referred to by its acronym, "RCRA" (pronounced "rick-rah"). RCRA defines which chemicals are regulated and requires that they be subjected to "cradle to grave" monitoring until they are destroyed, rendered non-hazardous, or buried in a special hazardous waste landfill.

Schools should try to reduce or eliminate as many of their waste streams as possible. If a school is not generating any hazardous waste, the associated disposal costs, potential spills, potential health and safety hazards, and record keeping requirements will not be applicable.

A chemical to be disposed of will be a regulated hazardous waste if it exhibits one or more hazardous characteristics (characteristic waste) or because it appears on one of four lists (listed waste).

9.2 Characteristic Waste

There are four types of characteristic hazardous waste: **ignitable, corrosive, reactive, and toxic**. These are referred to in the regulations as "D" wastes. The complete definitions of characteristic wastes can be found in 40 CFR 261.21-261.24 accessible from EPA's website:

www.epa.gov

Here are abbreviated definitions of these characteristic wastes:

- There are four reasons a waste could be classified as **ignitable:**
  - It is a ***liquid*** that has a flash point less than 140°F (60°C.) (The flash point is the temperature at which a liquid gives off enough vapor that the vapor will ignite if initiated by a flame or spark.) Examples are ethyl ether, most mineral spirits, ethanol, and gasoline.
  - It is ***not a liquid*** and is capable, under ordinary conditions, of causing fire through friction, absorption of moisture, or spontaneous chemical change. Examples are activated carbon, metal dusts, pyrophorics, and matches.
  - It is an ***ignitable compressed gas***. Examples are cylinders of hydrogen, acetylene, and propane, and aerosol cans using flammable gas as a propellant.
  - It is an ***oxidizer***; that is, capable of supporting combustion by contributing oxygen. Examples are oxygen, nitrates, peroxides, and hypochlorites.
- A **corrosive waste** is a ***liquid*** with a pH less than or equal to 2 or greater than or equal to 12.5; that is, it is strongly acidic or caustic. Examples are concentrated acids and concentrated ammonium hydroxide.

- A **reactive waste** exhibits one or more of the following properties:
  - It is ***unstable*** under ordinary conditions. An example would be any explosive, such as dried picric acid.
  - It ***reacts violently with water***, sometimes producing toxic, corrosive or flammable gases. Examples are alkali metals, acid anhydrides, phosphides and organometallics.
  - It is a ***cyanide or sulfide-bearing waste*** that, when exposed to a pH between 2 and 12.5, can generate toxic gases. Examples are potassium cyanide and sodium sulfide.
- The characteristic of **toxicity** refers to a waste from which harmful chemicals would leach if it were disposed of in a landfill. A test, the Toxicity Characteristic Leachate Procedure (**TCLP**, pronounced *T-clip*), is performed on the waste, and if the resulting leachate exceeds the allowable concentration of any one of 39 substances, the waste is a regulated hazardous waste. The list of these 39 chemicals can be found in 40 CFR 261.24. Examples are absorbent material used to clean up a spill of trichloroethylene, lead-based paint, and electronic equipment containing heavy metals. (It is not always necessary to have the TCLP test performed if you have sufficient knowledge of the waste to accurately predict whether it would pass or fail. For example, you would know that barium chloride would fail the test for barium, but barium sulfate would pass, because it is practically insoluble.)

9.3 Listed Wastes

The other category of hazardous waste is **listed waste**. There are four lists: **F, K, U** and **P**:

- **F-wastes** are mixtures from non-specific sources: for example, solvents used for cleaning.
- **K-wastes** are those produced by specific industrial sources; schools would not have any of these wastes.
- **U-wastes,** listed by name, are commercial chemical products.
- **P-wastes** are also commercial chemical products listed by name, but P-wastes are considered to be "acutely hazardous" and are more strictly regulated.

Most listed hazardous wastes generated by school laboratories would be on the U or P lists. All these lists are in 40 CFR 261.31-261.33 available at:

www.epa.gov

9.4 Determining if a Waste is Regulated

It is the responsibility of the generator of the waste to determine if the waste is hazardous. Checking to see if a chemical is on one of the lists is simple enough, but deciding whether a chemical or product is a characteristic waste might take a little research. The Material Safety Data Sheet (MSDS) for the material will usually provide enough information to identify characteristic wastes. Occasionally, a chemical or mixture may have to be tested to determine whether it is hazardous.

9.5 Determining Generator Status

There are three categories of hazardous waste generators. How much RCRA-regulated hazardous waste a school generates each calendar month determines its generator status and hence the degree to which it is regulated. It is the generator's responsibility to determine which category applies.

All non-exempted hazardous waste generated at the school must be counted to determine regulatory status: hazardous waste generated in science laboratories, art departments, vocational shops, grounds-keeping, maintenance and even in the nurse's office. Used oil and filters and used antifreeze that will be recycled, and items that can be managed under the Universal Waste Rule, such as hazardous batteries, fluorescent tubes, mercury-containing devices and certain pesticides, do not have to be counted toward the total.

Each school has its own generator status; this determination is not properly made for the school district as a whole. If you do not know your school's generator status, ask your principal, environmental safety person or the director of maintenance. The district office of the Florida Department of Environmental Protection in your region will also have a record of schools that have reported their status. District contact numbers are in the Appendix. The generator status can also be easily determined by reviewing hazardous waste disposal records, which are required to be maintained at the school for at least three years.

These are the generator categories:

- **Large Quantity Generators (LQGs)** produce more than 1000 Kg (about one ton) of regulated hazardous waste or one Kg of P-listed wastes each calendar month. LQGs must meet stringent requirements for storage, transportation, training, and record keeping. Research universities are usually LQGs.
- **Small Quantity Generators (SQGs)** produce between 100 Kg and 1000 Kg of regulated hazardous waste each calendar month and not more than one Kg of P-listed wastes. SQGs must abide by a simpler regimen of requirements addressing hazardous waste management. A few Florida secondary schools are SQGs.
- **Conditionally Exempt Small Quantity Generators (CESQGs)** produce less than 100 Kg (about 220 pounds) of hazardous waste each calendar month, and not more than one Kg of P-listed waste. Most Florida schools are CESQGs. CESQGs must abide by only a few simple regulations:
  - Determine if their waste is hazardous.
  - Not accumulate more than 1000 Kg of hazardous waste at any time.
  - Ensure that hazardous waste is delivered to an approved facility for disposal.
  - Maintain hazardous waste disposal records for at least three years.

The more stringent standards for SQG waste management are explained in Florida's Handbook for Small Quantity Generators of Hazardous Waste, a copy of which is on the CD that accompanies this handbook.

Note: It is easy to exceed the one Kg limit for P-listed waste, so the acquisition of these chemicals should be avoided whenever possible.

9.5.1 Hazardous Waste Generator Categories

Conditionally Exempt Small Quantity Generator (CESQG) Hazardous Waste Limits

A **CESQG** may generate in any one calendar month:

- no more than 100 kilograms (220 pounds - about half a 55-gallon drum*) of hazardous waste
- no more than 1 kilogram (2.2 pounds) of an acutely hazardous waste (e.g. some arsenic and cyanide compounds)

  and
- never accumulate more than 1,000 kilograms (2,200 pounds - about five 55-gallons drums) of hazardous waste at any time.

Small Quantity Generator (SQG) Hazardous Waste Limits

A **SQG** may generate in any one calendar month:

- between 100 kilograms (220 pounds - about half a 55-gallon drum) and 1,000 kilograms (2,200 pounds - about five 55-gallons drums) of hazardous waste

Large Quantity Generator (LQG) Hazardous Waste Limits

A **LQG** may generate in any one calendar month:

- 1,000 kilograms of hazardous waste (2,200 pounds - about five 55-gallons drums or more)

  or
- 1 kilogram (2.2 pounds) or more of an acutely hazardous waste

9.6 Disposal Options

- **You are a CESQG if you generate no more than 100 kilograms of hazardous waste in any calendar month.**
- **If you exceed the 100 kilograms per month or accumulate 1,000 kilograms at any one time, you are subject to the requirements of a Small Quantity Generator.**
- **Many counties have hazardous waste collection centers that will accept hazardous waste from Conditionally Exempt Small Quantity Generators for a reduced fee during scheduled collections.**
- **Contact your solid waste agency or DEP for more information (back cover).**

** These volume limits are based on the weight of water (8 pounds/gallon) and are only provided for the purpose of estimating one's status. Heavier wastes like heavy metal sludges (20 pounds/gallon) and chlorinated solvents such as perchloroethylene, freon, and trichloroethylene (12-13.5 lb/gallon) need to be evaluated based on their actual weight per gallon.*

Management and disposal options depend upon one's regulatory status. The larger the generator status, the more rigorous the requirements. However, even if your school is a CESQG, handling your waste as though your school were a regulated SQG is a wise strategy, as the mandated requirements are basically Best Management Practices. Also, many toxic school chemicals are not RCRA–regulated as hazardous waste. Nevertheless, these chemicals should be disposed of as though they were regulated hazardous waste because they are capable of causing harm to the environment.

Here are some hazardous waste disposal options to consider:

- **Give it away.** Circulate a list of the chemicals that you no longer need within your school district to see if someone else in the school system could use any of them. Remember, if the chemical still has a legitimate use, it is not a waste.
- **Treat it.** This option is allowed only for CESQGs (except for elementary neutralization, which any generator may perform). Some hazardous chemicals can be chemically destroyed. The Flinn catalog contains some examples of procedures to do this. Try this option only if you thoroughly understand the chemistry involved and have access to the proper equipment, including spill control supplies and PPE. Other procedures do not reduce the hazard of the chemical, but do reduce its volume so that disposal costs will be less. For example, heavy metal ions can be precipitated out of solution by the addition of the sulfide ion.
- **Take it to a household hazardous waste center.** Most Florida counties operate centers that accept household hazardous waste, and many will take hazardous waste from CESQGs as well. Always ask for permission first and expect to pay a fee.
- **Have a hazardous waste contractor come and get it.** (This is the only option for an LQG or SQG, as they may not transport their hazardous waste.) Contractors offer various degrees of services, including inventorying, identifying, packing, labeling and transportation to a treatment center. This is the most expensive option. Your school district may have a system whereby individual CESQG schools can send their waste to a central location where it can be processed and picked up by a hazardous waste contractor.

A hazardous waste manifest is associated with every shipment of hazardous waste. Hazardous generators are required to keep a copy of this manifest for three years and to be prepared to show it to DEP inspectors. CESQGs who take their waste to a household hazardous waste center should receive a receipt and keep it for three years.

The following are disposal options for chemicals that are **not technically hazardous,** but should still be disposed of with care:

- **Evaporate it.** This technique can reduce the volume of a hazardous solution, but is allowed only for non-hazardous solvents, like water. Evaporation is specifically forbidden as a disposal option for hazardous solvents.

- **Pour it down the drain – only with permission from your POTW!** Materials disposed of in a drain that goes to a Publicly Owned Treatment Works (POTW, or wastewater treatment plant) are exempt from RCRA regulation. This does not mean, however, that one can dispose of hazardous waste down the drain! POTWs have stringent pretreatment standards that must be met. Ask your POTW for a copy of these standards. As a practical matter, concentrations common to laboratory chemicals are far too high to meet these standards, and dilution to meet the standards is not permitted. Never pour the following down the drain: water reactive chemicals or chemicals that might react with metal pipes to form explosive compounds, such as picrates, perchlorates, and azides. ***Also, never dispose of any hazardous or non-hazardous chemicals to a septic tank,*** because doing so is not permitted and may cause the septic tank to malfunction and the groundwater may become contaminated.
- **Throw it in the trash.** Chemicals that are non-hazardous can be disposed of in a landfill or incinerator. However, because these facilities monitor the wastes that come to them and employees might not realize that the chemicals are harmful, ***it is important to ask for permission first***. If granted, hand-deliver the chemicals to the facility.

9.7 Types of Regulated Hazardous Wastes Commonly Found in Schools

Schools generate many types of hazardous wastes in different areas of the school. Examples include the following:

School Department	Hazardous Materials
Science Rooms and Laboratories	Flammable liquids (acetone) Oxidizers (bleach) Reactives (picric acid) Toxics (cyanides, phenol)
Technology Education (Graphic Arts, Printing)	Photographic chemicals Dyes Petroleum-based inks Cleaning products
Industrial Arts (Woodworking, Auto Repair and Metal Shops)	Degreasing solvents Petroleum solvents, stains, and paints Cleaning products Welding gases Used oils
Maintenance and Grounds-Keeping	Cleaning products Petroleum solvents Paints Pesticides Aerosols
Art	Petroleum solvents Glues and adhesives Oil-based paints Glazes with toxic metals Pigments with toxic metals Acids for etching

Chapter 10: Universal Waste Rule (UWR)

10.1 Purpose of the Universal Waste Rule

The Universal Waste Rule (UWR) of RCRA was enacted in 1995 to facilitate hazardous waste recycling. The UWR created streamlined regulations that govern the collection and management of certain widely generated wastes, termed universal wastes. Under the rule, EPA exempts universal wastes from the full scope of RCRA's hazardous waste regulations. Items regulated under the UWR do not have to be counted as hazardous waste when determining generator status under RCRA.

10.2 Items Covered Under the Universal Waste Rule

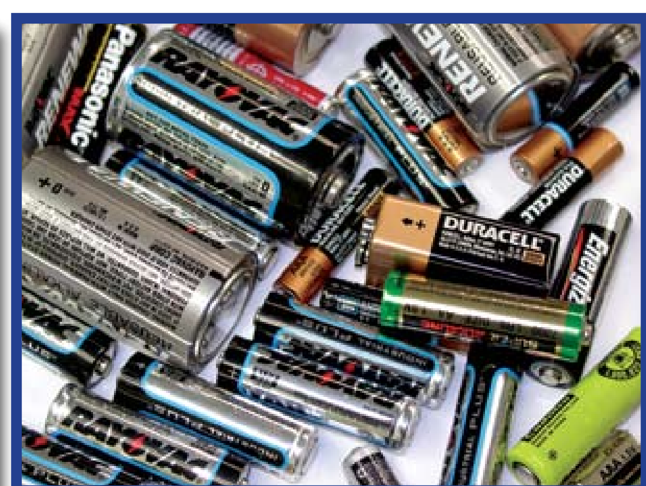
Universal wastes specifically mentioned in the rule include:

- Hazardous waste batteries.
- Mercury-containing devices (fluorescent lamps, thermostats, thermometers, etc.)
- Pesticides that have been recalled, suspended, or collected for discarding.

10.3 Facilities Regulated under the Universal Waste Rule

There are four regulatory categories under the UWR:

- Small quantity handlers: store less than 5000 kilograms of universal waste at any one time.
- Large quantity handlers: store 5000 kilograms or more of universal waste at any one time.
- Transporters: move universal wastes by air, rail, highway, or water.
- Owners or operators of destination facilities: treat, dispose of, or recycle universal wastes.



10.4 Requirements for Small Quantity Handlers

Most Florida schools are small quantity handlers of universal waste. There are several requirements for small quantity handlers under the rule. Small quantity handlers:

- Must prevent releases of universal wastes utilizing methods specified by EPA.
- Must immediately contain accidental releases.
- Must give detailed labeling on all universal waste containers.
- May store universal wastes for up to one year.

If a small quantity handler stores universal waste for longer than a year, the handler must establish that prolonged storage is necessary to facilitate proper recycling, treatment, or disposal. If a small quantity handler stores less than 100 kilograms per month of waste, a conditional exemption may exist from the Universal Waste Rule.

10.5 Requirements for Managing Spent Fluorescent Lamps

Fluorescent lamps constitute the majority of universal waste produced by schools. Although the amount of mercury in a single lamp is small, millions of them are discarded in Florida each year, making them a major source of mercury released to the environment. Spent fluorescent lamps (except those from households) have been banned from solid waste incineration facilities in any amount. It is permissible to dispose of up to ten lamps per month in a lined landfill, but many such landfills refuse to accept them in any amount, so always ask for permission before putting fluorescent lamps in the trash. Low mercury ("green") lamps can be disposed of in a landfill in any amount without violating the rule, but again, many landfills will not accept them. It is recommended that all lamps, regardless of quantity, be managed according to the requirements of the UWR:

- Store lamps in a manner that will prevent breaking. Do not over pack containers but do fill them up to lessen the chance that they will break during transit. Do not tape the lamps together. Recycling facilities may reject taped lamps.
- Label each container as "Spent Mercury-Containing Lamps for Recycling," "Universal Waste Mercury Lamps," or "Waste (or Used) Mercury Lamps."

- If lamps are broken, immediately contain them in a sealed container marked "Broken Spent Mercury-Containing Lamps for Recycling."
- Train employees in proper lamp handling, packaging, and emergency cleanup and containment procedures. Handle all supplies used in a lamp cleanup as hazardous waste.
- Lamps may be crushed in a drum-top crusher provided that OSHA standards are met, the crusher is properly maintained according to the manufacturer's written instructions, and employees using the crusher are thoroughly familiar with these procedures.

10.6 Managing Light Ballasts

Older ballasts contain polychlorinated biphenyls (PCBs), and about 25% of non-PCB ballasts contain di-(2-ethylhexyl)phthalate (DEHP), which is classified by EPA as a hazardous substance. Ballasts should not be disposed of in the trash. Recyclers that handle fluorescent lamps will also accept both PCB and non-PCB ballasts.

10.7 Managing Hazardous Waste Batteries

- Ordinary alkaline batteries may be disposed of in the trash.
- Other spent batteries, such as lead-acid, nickel-cadmium, lithium ion, and nickel metal hydride should be managed as universal waste. They should be collected in closed containers, labeled "Universal Waste Batteries," and disposed of within one year.
- Retailers that sell lead-acid batteries for automobiles, boats, aircraft, motorcycles, lawn mowers, etc. are required to take them back for recycling as trade-ins for new batteries. These batteries may also be sold to a battery recycling facility.
- Manufacturers of smaller sealed lead-acid batteries (less than 25 pounds) must provide a method of recycling them.
- Nickel-cadmium and other small rechargeable batteries may be disposed of through the Rechargeable Battery Recycling Corporation (RBRC). Visit their website at www.rbrc.org/call2recycle/. County Household Hazardous Waste Centers may also accept these batteries from schools.

Appendix 1: Chemicals with Severe Hazards

Chemical Name	Storage Category	Hazards
Acetaldehyde	Flam Cabinet	Suspect carcinogen. Highly flammable. Peroxide former. Severe irritant to eyes
Acetyl Chloride	Acid Cabinet	Corrosive. Reacts with water & alcohol
Acrolein (acrylaldehyde)	Flam Cabinet	Flammable. Inhalation toxin. Severe irritant. Many incompatibilities. P-listed
Acrylamide	O-3	Toxic by absorption, suspected carcinogen
Acrylic Acid	Flam Cabinet	Corrosive. Poison by inhalation & skin absorption. Flammable
Acrylonitrile	Flam Cabinet	Flammable. Poison by inhalation, skin absorption. Carcinogen
Adrenaline (Epinephrine)	O-2	Toxic. Theft risk. Drug Precursor.
Ammonia, gas cylinders	Poison Gas	Corrosive lachrymator, intense irritant, theft risk
Ammonium Bichromate	I-8	Powerful oxidizer, toxic, carcinogen
Ammonium Bifluoride	I-2	Caustic, poison, severe irritant. Reacts with water, forms hydrofluoric acid
Ammonium Chromate	I-8	Oxidizer, toxic, carcinogen
Ammonium Dichromate	I-8	Powerful oxidizer, toxic, carcinogen
Ammonium Perchlorate	I-6	Explosive; highly reactive
Aniline	O-2	Carcinogen, toxic, absorbs through skin
Aniline Hydrochloride	O-2	Poison
Antimony Trichloride	I-2	Corrosive; emits hydrogen chloride gas if moistened
Arsenic Oxide	I-4	Deadly poison & carcinogen. P-listed
Arsenic Trioxide	I-7	Deadly poison & carcinogen. P-listed
Barium Chromate	I-8	Toxic, oxidizer, carcinogen
Benzene	Flam Cabinet	Flammable. Carcinogen. Toxic
Benzidine	O-2	Carcinogen. Absorbs through skin. Avoid contact! Poison. Banned in many countries
Benzonitrile	Flam Cabinet	Toxic. Organic cyanide reacts with acids to produce poison gas. Combustible.
Benzoyl Chloride	Flam Cabinet	Corrosive. Combustible. Inhalation hazard
Benzoyl Peroxide	O-6	Organic peroxide, flammable, oxidizer
Beryllium	I-1	Poison. Dust is P-listed & highly toxic. Carcinogen
Bouin's Solution	O-8	Diluted picric acid. Explosive when dry.
Bromine, concentrated	Acid Cabinet	Corrosive, oxidizer, volatile liquid, poison fumes
Bromobenzene	Flam Cabinet	Flammable. Toxic. Bioaccumulative pollutant.

Chemical Name	Storage Category	Hazards
Cadmium Chloride	I-2	Toxic heavy metal, carcinogen
Cadmium Nitrate	I-3	Toxic heavy metal, carcinogen. Oxidizer.
Cadmium, powder	I-1	Carcinogen. Poison
Calcium Phosphide	I-5	Emits poisonous, flammable phosphine gas when wet
Calomel (Mercurous Chloride)	I-2	Extreme poison
Carbon Disulfide	Flam Cabinet	Flammable, poison, P-Listed, reacts with acids to form poisonous H2S gas
Carbon Tetrachloride	O-4	Toxic, carcinogen. Bioaccumulative pollutant
Carnoy's Fixative Solution	Flam Cabinet	Chloroform + acetic acid + ethanol. Flammable. Corrosive. Carcinogen
Chloral Hydrate	O-2	Hypnotic drug. Controlled substance
Chloretone	O-4	Poison. Narcotic. Controlled substance
Chlorine, gas cylinders	Poison Gas	Poison gas. Corrosive.
Chlorobenzene	Flam Cabinet	Flammable, toxic via inhalation & contact. Bioaccumulative pollutant
Chloroethanol	Flam Cabinet	Poison by skin absorption. Can produce acid gas. Flammable.
Chloroform	O-4	Carcinogen. If old forms deadly Phosgene gas. Bioaccumulative pollutant
Chlorophenol, p-	O-4	Poison by ingestion. Severe irritant. Bioaccumulative pollutant.
Chloroprene	Flam Cabinet	Flammable. Poison. Bioaccumulative pollutant. Affects central nervous system
Chlorosulfonic Acid	Acid Cabinet	Toxic inhalation hazard. Highly corrosive. Bioaccumulative pollutant
Chromic Acid	Acid Cabinet	Strong oxidizer. Poison. Carcinogen. Corrosive.
Chromium Trioxide	I-4	Oxidizer. Poison. Carcinogen.
Colchicine	O-2	Deadly poison. Affects cell division. Severe eye irritant.
Collodion	Flam Cabinet	Flammable. Explosive when dry. Ether/Nitrocellulose compound.
Copper Cyanide	I-7	Severe poison. P-Listed. Releases poison gas when acidified even slightly.
Corrosive Sublimate (Mercury Bifluoride)	I-2	Poison by ingestion and skin absorption (when wet). Corrosive.
Creosote	Flam Cabinet	Carcinogen. Combustible.
Cresol	O-8	Corrosive to skin & eyes. Toxic via ingestion, skin absorption.
Cumene	Flam Cabinet	Flammable. Central nervous system depressant. Peroxide former. Explosion risk.
Cyanogen Bromide	O-4	Poison. Corrosive. Reacts with acids to form poison gas.
Cyclohexene	Flam Cabinet	Flammable, peroxide former

Chemical Name	Storage Category	Hazards
Dichloroethane, 1,2- (ethylene dichloride)	Flam Cabinet	Flammable. Toxic. Bioaccumulative pollutant
Diethylamine	Flam Cabinet	Flammable. Corrosive to skin & eyes.
Dimethyl Aniline	Flam Cabinet	Combustible. Poison by ingestion. Irritant. Central nervous system depressant.
Dinitrophenol, 2,4-	O-4	Poison by inhalation, skin absorption. Explosive. "Bomb Squad"
Dinitrophenyl Hydrazine, 2,4-	O-4	Explosion risk
Dioxane, 1,4-	Flam Cabinet	Flammable. Peroxide former. Explosion risk.
Estrone	O-2	Steroid. Carcinogen. Theft Risk.
Ethyl Chloride	Flam Cabinet	Extremely flammable. Contact w/ water produces corrosive, toxic fumes.
Ethyl Ether (diethyl ether, anhydrous ether)	Flam Cabinet	Flammable. Peroxide former. Explosion risk.
Ethyl Iodide	Flam Cabinet	Combustible. Contact w/ water produces corrosive, toxic fumes
Ethyl Nitrate	O-4	Explosive. "Bomb squad"
Ethylenediamine	Flam Cabinet	Flammable. Toxic by inhalation. Corrosive base.
Ethyleneimine	Flam Cabinet	Flammable. Toxic. P –listed
Formaldehyde (37% Solution)	O-3	Toxic. Carcinogen. Severe sensitizer
Furfural	Flam Cabinet	Combustible. Toxic via inhalation & ingestion. Dangerous to eyes.
Gunpowder	Flam Cabinet	Explosive, theft risk
Hayem Diluting Fluid	I-2	Contains mercuric chloride. Severe poison.
Hydrazine	Flam Cabinet	Flammable. Poison by inhalation & skin absorption. Carcinogen. Corrosive to skin.
Hydrazine Sulfate	O-2	Poison. Absorbs through skin. Carcinogen.
Hydriodic Acid	Acid Cabinet	Corrosive. Toxic by inhalation
Hydrofluoric Acid	Acid Cabinet	Corrosive. Poison. Absorbs readily through skin
Hydrogen Sulfide, gas cylinders	Poison Gas	Poison. Inhalation hazard. Stench
Hydroquinone	O-2	Toxic by ingestion & inhalation. Corrosive to eyes & skin.
Isopropyl Ether	Flam Cabinet	Flammable, Highest-risk peroxide former. Explosive. Bomb squad.
Lead Chromate	I-8	Highly poisonous. Possible carcinogen. Commonly used in ceramic glazes.
Lead, powder	I-1	Poison
Lithium Aluminum Hydride	I-1	Flammable solid. Reacts with air, water & organics
Magnesium Perchlorate (Anhydrone)	I-6	Powerful oxidizer. Explosive reaction with alcohols.
Mercaptoethanol	Flam Cabinet	Flammable. Corrosive. Intense stench
Mercuric Chloride	I-2	Poison

Chemical Name	Storage Category	Hazards
Mercuric Iodide	I-2	Poison.
Mercuric Nitrate	I-3	Poison. Oxidizer
Mercuric Sulfate	I-2	Poison
Mercuric Sulfide	I-5	Poison. Reacts with acids to form poisonous hydrogen sulfide gas
Mercurous Chloride	I-2	Poison
Mercurous Nitrate	I-3	Poison. Oxidizer.
Mercurous Sulfate	I-2	Poison
Methyl Iodide (Iodomethane)	Flam Cabinet	May be a narcotic; Carcinogen. Lachrymator.
Methyl Isocyanate	Flam Cabinet	Flammable, dangerous fire risk, toxic
Methylamine	Flam Cabinet	Flammable. Corrosive. Intense stench. Inhalation toxin
Millon's Reagent	Acid Cabinet	Mercury nitrate + nitric acid. Deadly poison. Highly corrosive.
Naphthylamine, a-	Flam Cabinet	Combustible, Toxic. Carcinogen. Absorbs through skin or lungs
Nessler's Reagent	I-4	Mercury iodide + sodium hydroxide. Deadly poison. Corrosive.
Nicotine	O-2	Poison. P-Listed Extremely hazardous
Nitrilotriacetic Acid	O-1	Confirmed carcinogen. Toxic via ingestion.
Nitrobenzene	Flam Cabinet	Toxic. Combustible. Oxidizer. Absorbs through skin.
Osmium Tetraoxide (Osmic Acid)	I-4	Poison. P-Listed Extremely Hazardous.
Paraformaldehyde	O-3	Releases poisonous formaldehyde gas when heated
Paraldehyde	Flam Cabinet	Flammable. Controlled substance. Poison. Theft risk.
Pentachlorophenol	O-4	Extremely toxic. Bioaccumulative pollutant.
Perchloric Acid	Acid Cabinet	Powerful oxidizer. Highly corrosive. Potential explosive in contact w/ metals
Phosphorus Pentasulfide	I-5	Water Reactive. Toxic. Incompatible with air & moisture
Phosphorus Pentoxide	I-10	Oxidizer. Corrosive. Toxic.
Phosphorus, Yellow or White	Flam Cabinet	Spontaneously ignites in air. Poison.
Physostigmine	O-2	P-listed. Toxic
Picric Acid, Trinitrophenol	O-8	Explosive when dry. Explosive crystals form in contact with metals.
Potassium Cyanide	I-7	Severe poison. P-Listed. Releases poison gas when acidified even slightly.
Potassium Perchlorate	I-6	Powerful oxidizer. Reactivity hazard. Severe irritant.
Potassium Peroxide	I-6	Water reactive. Strong oxidizer.
Potassium Sulfide	I-5	Flammable. Unstable, may ignite spontaneously.
Potassium, metal	I-1	Water reactive, peroxide former (orange fog/crystals)

Chemical Name	Storage Category	Hazards
Pyridine	Flam Cabinet	Highly flammable. Toxic by ingestion, inhalation, skin contact
Silver Cyanide	I-7	Severe poison. P-Listed. Releases poison gas when acidified even slightly.
Sodium Arsenate	I-7	Deadly poison. Carcinogen.
Sodium Arsenite	I-7	Deadly poison. Carcinogen.
Sodium Azide	I-3	Poison, explosive reaction with metals. P-Listed Extremely hazardous
Sodium Borohydride	I-1	Flammable solid. Water reactive
Sodium Cyanide	I-7	Severe poison. P-Listed. Releases poison gas when acidified even slightly.
Sodium Hydrosulfite (sodium dithionite)	I-2	Water reactive. Toxic by ingestion & inhalation. An allergen. Powerful reducing agent.
Sodium Perchlorate	I-6	Powerful oxidizer. Reactivity hazard. Severe irritant.
Sodium Peroxide	I-6	Water reactive. Strong oxidizer.
Strontium	I-1	Flammable. Store under naphtha. Water reactive.
Sulfur Dioxide, gas cylinder	Poison Gas	Poison gas at high levels. Corrosive irritant to eyes & skin.
Testosterone & Testosterone Proprionate	O-2	Controlled substance. Steroid. Theft risk.
Tetrahydrofuran	Flam Cabinet	Flammable. Peroxide former. Explosion risk.
Thallium	I-1	Extremely poisonous.
Thioacetamide	Flam Cabinet	Toxic. Carcinogen. Combustible.
Thionyl Chloride	Acid Cabinet	Corrosive. Violent reaction w/ water forms acid gas.
Thiourea	O-2	Carcinogen. Poison.
Titanium Tetrachloride	I-2	Toxic inhalation hazard. Highly corrosive.
Titanium Trichloride	I-2	Corrosive. Reacts with water & heat to produce corrosive, toxic fumes.
Trichloroethane	O-4	Toxic. Ozone depleting chemical. Bioaccumulative pollutant.
Trichloroethylene	O-4	Toxic via skin, inhalation. Ozone depleter. Bioaccumulative pollutant. Carcinogen.
Triethylamine	Flam Cabinet	Flammable. Toxic. Irritant.
Trinitrobenzene	O-3	Explosive. "Bomb Squad"
Uranyl Nitrate	I-3	Radioactive. Toxic by ingestion. Oxidizer. Corrosive to skin.
Vanadium Pentoxide	I-4	Poison via inhalation & ingestion.

Appendix 2: Peroxide-Forming Chemicals

Apx 2.1: Severe Peroxide Hazard

Spontaneously form explosive peroxides once opened. Chemicals should be disposed of as hazardous waste within three months of opening.

Butadiene (liquid monomer)
Chloroprene (liquid monomer)
Isopropyl ether
Potassium amide
Potassium metal
Sodium amide
Tetrafluoroethylene (liquid monomer)

Apx 2.2: Peroxide Concentration Hazard

Chemicals that form explosive peroxides when distilled, evaporated or otherwise concentrated. These chemicals must be tested for peroxides and discarded within six months of opening.

Acetal
Acetaldehyde
Benzyl alcohol
2-Butanol
Cumene
Cyclohexene
Cyclohexanol
Diethyl ether (Ethyl ether)
Diethylene glycol dimethyl ether (diglyme)
1, 4-Dioxane
Ethylene glycol dimethyl ether (glyme)
4-Heptanol
2-Hexanol
Methyl isobutyl ketone
2-Pentanol
2-Phenylethanol
Tetrahydrofuran

Apx 2.3: Shock and Heat Sensitive

These chemicals form explosive peroxides from auto-polymerization and internal peroxide accumulation. The liquid chemicals in this group should be tested for peroxides and discarded within six months of opening.

Acrylic acid
Acrylonitrile
Methyl methacrylate
Styrene
Vinyl chloride (gas)

Notes

Notes

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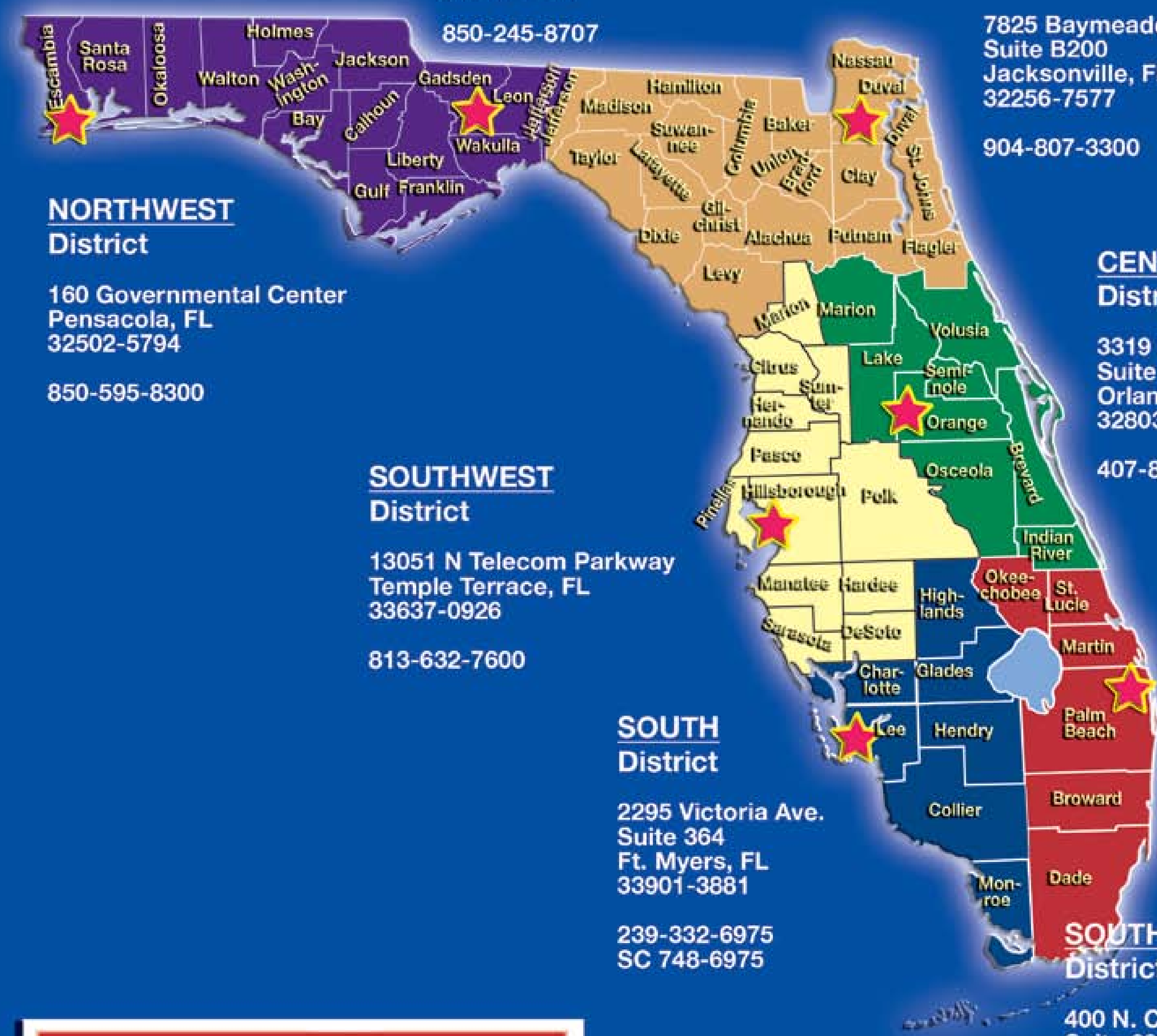

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