Study of Small Storage Areas on Campus

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As part of a team of students looking at problems of chemical inventory purchasing, handling procedures and storage on campus, I focused on small campus storage areas. Campus storerooms with relatively large daily flows of chemicals often contain large volumes of each chemical, ready to be dispensed as needed. The Chemistry Department, which stocks chemicals for many large laboratory classes, has such storerooms. For example, this Department presently orders about 3000 gallons of acetone solvent per year (Getz, pers. comm., 1988) and regularly dispenses it to students. Thus, this chemical does not stay on the shelf for extended periods of time. I look at storerooms of a different kind, those which store small amounts of a variety of chemicals, often for extended periods of time. These situations present special storage and inventory problems. The goal of this study is to determine the inventory, storage, and disposal methods presently used in small storerooms, and any problems which may be involved, as well as to to suggest improvements in these methods.

I use two small storerooms on the U.C. Berkeley Campus for study. Because the storerooms inventoried were promised anonymity, no personal communications are identified by name. I will refer to the study areas as Storerooms A and B. The department housing Storeroom A will be moving to new quarters soon, presenting an opportunity to evaluate the needs of a new storeroom with regard to storage and disposal of hazardous chemicals and hazardous waste. Storeroom B is a good study site for several reasons. First, the chemicals are likely to remain in storage for long periods of time before being completely used. This presents an occasion to study problems likely to be encountered in long-term upkeep and organization of a chemical storage area. Also, there is no inventory for the shed. My inventory will make any necessary re-organization easier for those involved.

Past Studies

I found no previous studies of chemical storerooms on campus. *School science laboratories: a guide to some hazardous substances* (National Research Council, 1984) was a helpful manual for general methods and safety guidelines, as was *A guide to the safe storage of laboratory chemicals* (EH&S, 1986).

Background

The Introduction to the Inventory Section in this report describes the general purposes and goals of the inventory group. It also covers the relevant aspects of government legislation relating to chemical storage and disposal, chemical compatibility classes and general methodology used by the inventory group. A review of the introduction is recommended, since much of the information is important for understanding this study.

Maintaining accurate inventory is important in a storeroom. Chemicals may be on shelves for extended periods of time. Some of the chemicals I inventoried had been on the shelf for ten years. Updating inventory allows the storeroom manager to find and dispose of corroding containers or dangerously old chemicals. Time invested in inventory upkeep will reduce time involved in finding a chemical whose location is not on file, or in identifying a chemical whose label has fallen off and for which there is no record. Such an inventory also makes chemical disposal easier, since containers are already labeled and separated into hazard classes.

The Superfund Amendments and Reauthorizartion Act (SARA) to the Federal Resource Conservation and Recovery Act (RCRA) described in the Legislative Background section of the Introduction, requires a facility with hazardous chemicals on site to provide an estimate of chemical types present, in both daily and annual quantities. Periodic inventory checks and immediate updates will aid in compliance with this regulation.

Separation of incompatible chemicals is important in a storeroom with relatively small amounts of many chemicals because there are likely to be many incompatibles which could mix should an earthquake or other emergency occur. Compatible chemicals can be safely stored together, since they are not likely to cause a dangerous reaction when in contact with one another. The most common classes are described in the general introduction. Briefly, they are: flammables and combustibles, corrosives, toxics and poisons, peroxide formers, cryogens, pyrophoric substances, and water-reactives. These classes can be further divided, for example, into corrosive acids and corrosive bases, as well as expanded, perhaps to include categories for carcinogens and irritants.

Storeroom A stores chemicals for "stop-gap" use. If a researcher needs a chemical immediately, he or she is given what is on the shelf. Otherwise, each lab sends its orders to the storeroom lab assistant, who then orders chemicals in batches. These are not commonly kept in the storeroom, but sent directly to labs for storage and use (pers. comm., 1987). Consequently, chemicals in Storeroom A may be on the shelf for several years before use.

Storeroom B, a storage shed, is quite different from Storeroom A. It is isolated from the laboratories at the facility, and is designed for storage of large amounts of flammable liquids. The shed is surrounded by a locked fence to control access, and has a sprinkler system in case of fire. Because there is no door, all contents of the shed experience a broad range of temperatures, as well as changes in light and humidity. Corrosion of metal containers and decay of paper products are results of this exposure. The shed is used for storage of shop products, solvents and various other chemicals used in experimental projects. There are eight different projects which have chemicals stored in the shed. Each project leader is assigned several shelves for storage of chemicals and is required to keep an inventory of project chemicals in the storeroom. There is no overall inventory, however (pers. comm., 1988).

Methodology

My inventory methods were similar to those described in the methodology section of the Introduction. I inventoried the storerooms using inventory sheets in Appendix B. I identified chemical compatibility classes using reference books such as *Dangerous Properties of Industrial Materials* (Sax, 1984), *The Hazardous Chemicals Data Book* (Weiss, 1980) and MSDS sheets, and used these data to compile the information in the Data Section. The methodology section in the Introduction contains more detailed information on general methodology.

In addition to the chemical classes that are described in the hazard class section of the Introduction, I included 'suspected carcinogens ', 'known carcinogens', 'irritants' and 'non-hazardous' categories. Class A and B carcinogens should be stored with their appropriate families, benzene with flammables for example, and labeled as carcinogens. Class C carcinogens should be stored in a glove box. Irritants are materials which irritate the skin, eyes, or lungs and may be slightly toxic or corrosive. They should be stored on shelves with rim guards and handled according to directions. Non-hazardous substances are not likely to cause a hazard if spilled, but should be treated with care in any case (EH&S, 1986). I divided the flammable and combustible category into two separate categories, each with its own solid and liquid categories, to give a better idea of the ratios of these forms present in the two storage areas. I also counted the number of items present by general type: lab chemicals, photographic chemicals, dyes, and shop products such as motor oil or paint. I used a checklist (Table 1) to record the general safety features of both storage areas.

	Storeroom A	Storeroom B
	yes/no notes	yes/no notes
Storage area		
Marking of area contents	no	some shelves do
chemicals stored in fume hood	no fume hood	no fume hood
clear aisles	yes	chem. on floor
open sourceof flame	no	no
smoke detector	?	no
fire extinguisher	?	yes, inspected
spill clean-up materials	no	no
eyewash/shower	?	yes, but water rusty
phone/numbers	yes	no
charts of chem. compatibility	no, but many books	no
posted guide for chem. disposal	no	no
Storage Shelves		
chem. stored in unsafe areas	some sheves no guards	yes
raised shelfguards	yes, most shelves	no
chem. stored away from heat	yes	sun comes in door
cylinders secure	none	one is not

Table 1 Checklist of General Safety Features

The Hazard Class section of the introduction contains the hazard class hierarchy used by the inventory group in classifying chemicals. When a chemical belonged in more than one hazard class, it was assigned the class highest on this list. Thus, a chemical which was both an oxidizer and an irritant was put in the oxidizer category. This heirarchy excludes several of the categories I used. The chemicals in the 'carcinogen' and 'suspected carcinogen' categories were also toxic or, in the case of benzene, flammable. Most of the peroxides I found were also flammables, though one was a poison, and one, acetaldehyde, a flammable, irritant and possible carcinogen. I have listed peroxidizables, carcinogens and possible carcinogens separately because these chemicals have properties which make them more important than flammables or toxics from a storage standpoint. The hazardous properties of carcinogens are obvious. Peroxidizable chemicals can form peroxides over time, which can explode without warning.

Labels in both storage areas were sometimes unreadable or missing. I gathered as much information as possible in these cases. If I could not determine the name, I included the item as an unknown. Items without labels were also included in this category. In cases where liquid amounts were given in units of weight only, I recorded the weight listed on the label, as well as estimating the volume.

Although most of the inventories for this project were conducted by teams, I inventoried Storeroom A alone for about two-thirds of the time, with the lab assistant present. Otherwise, my methods were the same as those described in the overall methodology in the Introduction.

Several changes in methodology were made in inventorying Storeroom B. I worked alone while inventorying common shop products such as paints and machine lubricating oils. Although in other inventory projects the chemical manufacturer was not recorded due to time constraints, I recorded this information because I considered it an important part of the only existing inventory of the Storeroom. The inventory is not complete due to a considerable number of potentially explosive peroxidizable chemicals which blocked access to chemicals at the rear of several storage shelves. There are approximately 10 - 15 chemicals excluded from the inventory for this reason.

Data Presentation

The checklist made for each location (Table 1), shows the presence or absence of general safety features recommended for chemical storage areas. Table 2 summarizes the number and amounts of the chemicals in the storerooms. The number of items, as well as solid weights and liquid volumes are given in each chemical category for each study area.

Storeroom A: The chemical stock in the present Storeroom A is quite small. Overall, there are far more solid materials than liquid, about 82 pounds of solids compared to 53 gallons of liquid. Of a total of 160 items, the majority, 130 items, are lab chemicals. The other general categories contain small numbers of items (Table 2).

Corrosives, such as acetic anhydride and boric acid, are the largest hazard class represented in Storeroom A, with 29 items amounting to 17 pounds of solids and about 7 gallons of liquids. Irritants are the next most numerous class. This group of 28 items is made up of 30 pounds of solids such as potassium chloride, with only 3 ounces of liquid.

	Storeroom A		Storeroom B	
total number of items	160		552	
total amount*	53 gal, 93.6 lb.		l292 gal., 40 lb.	
General use types	# items		# items	
lab chemicals	130		412	
photo chemicals	8		0	
shop products	6		119	
dyes	11		0	
Compatibility class	# items	amount *	# items	amount*
flammable liquid	21	8.3 gal.	212	610 gal.
flammable solid	7	3.2 lb.	0	------
combustible liquid	3	9 fl.oz., 0.5 oz	49	119 gal.
combustible solid	1	0.6 lb.	0	------
corrosive	30	7.2 gal., 18 lb.	67	121.0gal.
oxidizer	17	10.6 lb.	2	0.4 gal.
poision	19	6.0 gal., 7 lb.	47	74.0 gal.
irritant	28	3 oz., 30.5 lb.	49	23.0 gal., 38 lb.
peroxidizable	0	-----	23	78.0 gal.
suspected carcinogen	2	0.4 gal.	0	------
known carcinogen	3	2.1 gal.	26	10.8 gal.
unknown **	3	?	20	191 gals.
non-hazardous	11	3 oz., 12 lb.	4	1.5 gal., 2 lb.
unidentified hazard class	7	28 0gal., 12 lb.	37	24.0gal.

* liquid amounts given in gallons or fluid ounces, solid amounts given in pounds.
** The "unknown" category includes chemicals lacking labels, and those with unreadable labels.

Table 2 Comparison of number of items and amounts of chemicals in Storeroom A and the Storeroom B

The flammable liquids and solids groups also contain 28 items when combined. Although there are a large number of items in this class, the amounts are much smaller than in the corrosive or irritant classes. The poisons category contains 19 items, 7 pounds of solid, and 6 gallons of liquid, such as bromoform. The oxidizer hazard class contains 17 items, all solid, such as ammonium nitrate, amounting to 11 pounds.

There are three known carcinogens. These are p-dioxane, chloroform, and carbon tetrachloride. The two suspected carcinogen items are formalin. Although these groups contain relatively small amounts, their carcinogenic and toxic properties make them relatively important.

There are three unknowns, whose amounts are also unknown because the containers are sealed or unaccessible. Seven items could not be identified by a hazard class, because they were not found in any of the references. This group comes to quite a large amount, 28 gallons of liquid and 12 pounds of solids.

The combustible solids and liquids categories do not contain many items, nor large volumes. These are mainly oils such as tung oil. There were no peroxides in this storeroom.

Although safety items such as eyewash and shower are not present, this storage area is quite neat and clean. The chemicals are stored alphabetically by chemical name, on shelves with rim guards. The inventory is hand-written on inventory sheets (pers. comm., 1987).

The storeroom also contains a large number of resources concerning chemical safety and emergency procedures. The checklist, Table 2, gives information concerning safety features in more detail.

The volume of waste produced by the Storeroom A itself is negligible. However, the storeroom is the Department's disposal center. Waste from the labs is brought to the storeroom, where it is packaged by the storeroom lab assistant for disposal by EH&S (pers. comm., 1987).

Storeroom B: The 'general use type' categories on Table 1 show that most chemicals in this storeroom are lab chemicals, 412 items. There are also a significant number of shop products, 119 items.

The largest hazard class represented is flammable liquids, with 212 items amounting to 610 gallons. The majority of these are solvents such as acetone and isopropyl alcohol. Corrosives are also well represented. The 67 items are all liquids, about 121 gallons. The 49 items in the irritant category are made up of 23 gallons of liquids and 38 pounds of solids. The combustible liquids category, which includes such items as vacuum pump oil, is large. There are 47 poison items, totaling 74 gallons.

Storeroom B contains a relatively large amount of carcinogens. There are 26 items, about 46 gallons. Examples are formaldehyde, p-dioxane and benzene. Twenty-five peroxidizables, such as 1-4 dioxane and ether, are present, totaling about 78 gallons.

Twenty unknowns, about 190 gallons, are recorded. These are unknowns mainly because exposure has decayed labels, though some items have no label. A significant number of chemicals, 37 items, could not be identified as belonging to any hazard class. The majority of these are small bottles of sulfur chemicals. There is an insignificant amount of oxidizers. The two items come to less than 1 gallon, compared to the 10 pounds found in Storeroom A.

The volume of waste produced by the shed is small. Since all chemicals in the storeroom beside shop products are for specific projects, any waste from Storeroom B is taken to project work sites by individual project leaders, where it is packaged, along with other waste from the project. The waste from each laboratory is then taken to a specific site for pick-up by...personnel who hold the materials at a central site for disposal by EH&S (pers. comm., 1988). This process is supervised by the Safety Officer .

Comparisons: There are far more items in Storeroom B than in Storeroom A, 552 items, compared to 160 items. Of these 552 items, the majority are in liquid form, about 1300 gallons, compared to Storeroom A, where the majority of items are in solid form. There are relatively fewer non-hazardous items in comparison to Storeroom A. Although there are far greater number of unidentified chemicals in Storeroom B, the amount is much smaller relative to the total amount, when compared to Storeroom A.

Far more of the metal containers and labels in Storeroom B showed corrosion and decay than in Storeroom A. Periodic re-labeling and replacement of corroded containers is done in order to combat this problem. Plastic bags are placed over many of the containers to slow the process of decay as well.

A problem in both storage areas is the lack of dating to indicate the age or the expiration date of chemicals. Although most of these chemicals have no expiration date, peroxidizable chemicals should be discarded at most 12 months from opening since they become potentially explosive with time. The lack of dates is a also problem in Storeroom B because without an inventory, there may be no other way to know how long a chemical has been in storage. Inspection dates are helpful on all chemicals, since they indicate when another inspection is due.

Discussion and Recommendations

General re-organization and improvement of storage systems is necessary in both storage areas. The Storeroom B also requires a reduction in amounts of peroxidizables stored past their expiration date, as well as an inventory system. Following are more detailed recommendations for each storage area.

Storeroom A: The main goal when organizing the new Storeroom should be separating incompatible chemical classes. Two storage cabinets for flammables would allow storage of these chemicals in a safe manner. The flammable shop products, such as hydraulic oils, should be stored in these cabinets, along with lab and photographic products. Because the State Fire Marshal's office allows no more than 50 gallons of flammable liquids in any storage area (EH&S, 1986), a reduction in these liquids is recommended. Since these chemicals are seldomly used, reduction should be feasible. In some cases, there are partially full containers stored with full containers of the identical chemical. Disposing of these partially full containers would reduce volumes, as would discarding chemicals unused for over a year.

A corrosive-resistant cabinet, or plastic safety trays, are recommended for storage of the large group of corrosive chemicals in the storeroom. Corrosive chemicals should be isolated from other chemicals, although not necessarily in special cabinets. The hazard classes within the corrosives group should be separated as well. For example, corrosive acids should not be stored next to corrosive bases. Storage below eye level is recommended, because corrosives can cause blindness if spilled in the eyes.

It is important to keep poisons isolated and cool. Some of these chemicals, such as p-dioxane and carbon tetrachloride, are carcinogenic. They should be stored with their appropriate class, but clearly marked as carcinogenic. Oxidizing chemicals should be separated from other families, and stored in a cool, dry place.

The group of chemicals in the 'irritant' class can be stored on shelving with rim guards, separate from other groups. They should be handled with caution, according to any precautions on the label. Non-hazardous chemicals can be stored on shelves with rim guards.

Since Storeroom A is also the department's disposal center, an area in the new storeroom for disposal preparation is recommended. This area should have a fume hood for noxious wastes, safety equipment such as eyewash and shower, and ample work and storage areas. A small flammables cabinet for temporary storage of flammable waste is recommended. Inventory should include a separate record for all chemicals disposed of, including the laboratory of origin.

Storeroom B: The presence of potentially explosive peroxidizable chemicals, which have been stored longer than 12 months, is dangerous. Consequently, a reduction in the amount of these chemicals is desirable. A number of the shop products appear to be quite old. A review of these items is recommended, in order to discard items such as dried out paint cans. Although there are large amounts of solvents in Storeroom B, work done in projects requires these quantities. Further, the Storeroom is built especially for storage of these chemicals, as described in the background section. These two factors make a great reduction in the amount of solvents unnecessary.

A problem involved in outdoor storage is the corrosion of metal containers and decay of paper products, such as labels and cardboard boxes. Labels which have fallen off or are unreadable make it impossible to know whether or not chemicals may be dangerous. Although current periodic re-labeling, bagging and replacement of corroded containers is essential to combat this problem, more frequent inspections are necessary. Improving and expanding data available on all labels is important. Flammable storage cabinets would help to slow corrosion and decay by offering protection from the elements.

The fact that the shed is used for storage of chemicals for eight separate projects results in crowded storage shelves. Lack of space prevents all chemicals being stored according to compatibility classes. As a result, there are incompatible chemicals stored together in corroding containers. An accident would not be unexpected under these conditions. A solution would be to design separate areas for each compatibility class, and require project workers to store their chemicals in these respective areas. Requiring researchers to re-label their chemicals, to include a name and phone number, would be necessary.

A waste collection area is not necessary in the shed itself, since all waste is processed for disposal in another area. The waste disposal process is described in the data presentation section.

High cost of chemicals is one factor affecting the amount of chemicals in both storage areas. Researchers often prefer to keep chemicals with long shelf lives, rather than dispose of them and invest in more chemicals later. Thus, while chemicals may appear to be unused, in fact they may be intended for use in the future (pers. comm., 1988).

Conclusion

Storeroom A is probably representative of many small storage areas on campus. Because the storeroom does not have high usage, the chemicals may sit on the shelf for some years before being used. The chemicals are stored alphabetically, or in some manner other than hazard classes. The storage area manager is willing to make improvements.

A continuously updated inventory, as well as a policy for disposing of dangerous chemicals stored without use for a certain time, are needed in Storeroom B. Researchers need to be aware they are responsible for the safe storage of their chemicals. Recording the project leaders name on each chemical, and each storage shelf, is important.

The storage patterns of these smaller storerooms have not been scrutinized in the past for several reasons. The departments often have too many other important things to do, with little time to study storage guidelines and inspect labs and storage areas. Also, this subject has not been thought of as a real problem in the past, as conciousness about the problems of hazardous chemicals and waste has only recently been widely raised. A study of the inventory and storage needs of all storerooms on campus is necessary to improve methods and raise conciousness.

One recommendation for a campus-wide inventory project is a standard labelling system, which will eliminate the trouble and time spent on the part of individuals or departments in creating such a system. An easy-to-use, readily available system may encourage chemical users to adopt a more organized storage policy.

There are other general steps which could be taken to reduce the amount of old or unused chemicals presently on campus, and to reduce the amount of chemicals wasted or disposed of in the future. A campus-wide newsletter would aid greatly in the reuse of unused, viable chemicals. A more intensive general education of campus staff about the dangers of hazardous chemicals and waste may help prevent the problem, as opposed to having to create ways to deal with the problem once it exists.

My study of small storerooms has shown an overall need to improve inventory practices. This is especially important if a campus-wide inventory system is a goal. Disposal of old or dangerous chemicals and organization of remaining ones into compatibility classes are the two next most pressing needs.

A campus-wide study is necessary to ascertain the scope of the inventory and storage problems. However, without support and perhaps enforcement of such a program from campus authorities, the problems will probably continue. In order to solve the entire problem of hazardous waste on campus, these issues must be addressed.

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