Storing Hazardous Chemicals in the Academic Laboratory: A Guide Toward a Safe, Efficient Laboratory

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Introduction

This report presents a study to improve the storage of hazardous chemicals in academic laboratories on the U.C. Berkeley campus. From the initial stage of estimating chemical stock to the final stage of recommending action, this report provides the laboratory manager of an academic laboratory with basic guidelines needed to improve chemical storage.

However, before these guidelines are applied, certain aspects related to achieving safe storage of hazardous chemicals must be understood. Because the U.C. Berkeley campus is a state-controlled institution, only federal and state regulations affect chemical storage – local regulations do not govern. In addition, because storage regulations differ from state to state, the conclusions drawn are specific to academic laboratories in California. Ultimate responsibility of planning lies with the laboratory manager, and it is recommended that consultants be retained should complications or uncertainty arise.

Past Studies

Although there are no specific studies on chemical storage in U.C. Berkeley academic laboratories, a number of works offer valuable guidelines for the safe storage of hazardous chemicals. One book that gives practical, up-to-date advice on a broad range of laboratory planning questions is *The chemical laboratory: its design and operation* (Rosenlund, 1987). It is a general treatment and should be supplemented with other sources.

A source which treats laboratory safety in great detail is the *Handbook of laboratory safety* (Steere, 1971). This book gives a good introduction to lab safety, although it was written some time ago. A more up-to-date treatment of lab safety can be found in *Prudent practices for disposal of chemicals from laboratories* (National Research Council, 1983). This book is also a good introduction on dealing with hazardous wastes in the laboratory. The most useful source was *A guide to the safe storage of laboratory chemicals* (EH&S, 1986). This pamphlet provides valuable, concise information on principles of chemical storage. Some of the topics include taking an inventory, labelling, and separating incompatible chemicals.

The Merck Index (Windholz, 1983) and *Dangerous properties of industrial materials* (Sax, 1984) are two chemical reference books which help to identify a chemical's hazard classification, with the latter being the more useful.

Background

A decision to improve chemical storage in an academic laboratory requires knowledge of appropriate regulations, a basic understanding of safe storage principles, and a flexible data structure in which to manipulate information before any attempt is made to identify storage problems. For example, the State Fire Marshal's Office limits laboratories on the Berkeley campus to the storage of 50 gallons of Flammable liquids, of which up to 20 gallons may be stored outside of a flammable storage cabinet. Any amount over 20 gallons (up to 30 gallons) must then be stored in a flammable storage cabinet. Ignorance of this requirement could result in delays later in the study if, after estimating chemical stocks, further observations must be made to determine whether the chemicals were stored in a flammable storage cabinet. Likewise, a lack of knowledge concerning safe storage principles could result in failing to recognize unsafe storage practices. But aspects of regulations and knowledge of storage principles are, by themselves, merely the foundation. A data structure is needed to provide the framework from which accurate assessments can be made of each lab's chemical storage. (Further information on regulations and safe storage principles is found in the Introduction to the Inventory Section.)

This report uses a hazard class framework adopted by the University's Office of Environmental Health and Safety (EH&S). A hazard class, representing a group of chemicals with similiar physical and chemical properties, describes a specific danger when certain conditions are met. For example, a chemical of the Flammable hazard class will ignite quickly if placed over a strong heat source. An additional problem addressed by the use of hazard classes is that mixing chemicals of differing classes is potentially dangerous. Thus, the use of a hazard class framework reinforces the idea of incompatibility between two dissimiliar chemicals. The hazard classes used in this report include: Combustible, Corrosive, Flammable, Oxidizer, and Toxic. Further information on hazard classes and incompatibility can also be found in the Inventory Section Introduction.

Methodology

Eight laboratories in a U.C. Berkeley science department were inventoried in November of 1987. Data collection followed the general methodology found in the Introduction to the Inventory Section. Inventory data sheets were prepared in tabular form to record a broad range of information (because unnecessary data could always be excluded later), including not only estimates of chemical amounts, but also container types and names of manufacturers. Chemical amounts estimated at less than 0.1 liters or 20 grams of solid are considered negligible and are not included in the tally.

The actual inventory was conducted over a two-week period. As the inventory progressed, it became apparent that data collection was most efficient with a team of two people — one to read and the other to record the information on the prepared inventory sheets. But because of scheduling conflicts, inventories were often done alone. Efforts to increase efficiency resulted in the development of a shorthand notation, the use of a tape recorder, and an attempt to develop a step-by-step procedure for inventorying a lab.

Observations of the laboratory environment were made concurrent with the inventory, because such factors as ventilation, temperature, and placement of storage cabinets and fume hoods need to be considered to determine what needs improvement. The temporary storage of hazardous waste was also noted since hazardous substances need special storage precautions.

With the completion of the inventory, listed chemicals were separated by hazard class. Reference books on chemical properties were somewhat helpful in classifying the more difficult substances. Chemicals which could not be classified into the hazard classes were considered unidentifiable and were listed in the "Other" category. Unknown chemicals, from containers which were inadequately labeled, were not included in this report. (Percentage estimates of unknowns are 0.85% for liquids by volume and 5.11% for solids by weight.) Following the separation into hazard classes, the data were then evaluated in terms of the appropriate regulations, as a check that the laboratory was in compliance. Finally, recommendations for proper storage were generated for three typical labs. This required taking into account safe storage principles, available space, and needs of investigators to decide the types of storage facilities needed, where they might be located, and how many would be appropriate.

Data

Table 1 presents estimates of total chemical stock, organized by hazard class, for each academic laboratory. Corrosive liquids (nearly 600 liters) and Flammable liquids (209.5 liters) are the most abundant in the laboratories studied.

The chemicals in Room A consist, for the most part, of Flammable liquids (12.0 liters) and "Other" liquids (36.0 liters). A large amount of the Flammable liquids consists of acetone; the "Other" liquids are mainly glues and resins. Observation of the room indicates that dust is potentially a significant maintenance problem.

Room B contains a large amount of Corrosive liquids (554.0 liters), consisting mainly of four 55-gallon drums: one each of acetic acid and formic acid, and two of hydrochloric acid. It was observed that the drums were corroding on the outside.

The 70.0 liters of "Other" liquids in Room C consist of a polyester resin. This resin was stored together with the Flammable liquids (acetone and gasoline) in a flammable storage cabinet.

The significant totals of Room D include 27.0 liters of Corrosive liquids, 150.0 liters of Flammable liquids, and 58.9 kilograms of "Other" solids. The Corrosive liquids include such dangerous chemicals as hydrofluoric acid, nitric acid, and potassium hydroxide. A 150-liter drum of t-butyl alcohol, stored outside of a flammable storage cabinet, represents the sole source of Flammable liquids. The "Other" solids consisted in large measure of zinc bromide and zinc chloride. Observation of this room showed good storage practices — large bottles were enclosed in styrofoam jackets to provide an extra degree of safety; extremely hazardous chemicals were handled in small plastic squirt bottles. This room was also the only one which collected hazardous wastes (in the form of used squirt bottles) and stored them, informally, in a separate area.

The hazardous chemicals in Rooms E, F, and G are stored in laboratory cabinets with little regard for organization. Chemicals were usually found in small containers. In addition, Rooms F and G were the only labs having at least a trace of a Toxic solid.

Room H, which was the largest of the inventoried labs, contains a large variety of chemical types. Many empty containers or containers with unknown compounds were observed but were

Hazard Class	Combustible		Corrosive		Flammable		Oxidizer		Toxic		Other	
	Solid (kg)	Liquid (L)	Solid (kg)	Liquid (L)	Solid (kg)	Liquid (L)	Solid (kg)	Liquid (L)	Solid (kg)	Liquid (L)	Solid (kg)	Liquid (L)
Room A	--	--	--	--	3.2	12.0	--	--	--	5.0	2.4	36.0
Room B	--	--	--	554.0	--	12.0	--	--	--	--	--	--
Room C	--	--	--	--	--	6.0	--	--	--	--	--	70.0
Room D	--	1.8	6.7	27.0	--	150.0	--	--	--	0.5	58.9	2.0
Room E	--	--	--	0.5	--	--	--	--	--	1.0	--	3.0
Room F	--	--	--	11.0	--	2.0	--	--	0.3	--	1.8	10.0
Room G	--	--	0.9	1.0	--	0.5	--	--	trace	--	1.1	1.0
Room H	0.3	1.0	0.9	6.0	0.1	27.0	0.2	--	--	3.0	7.1	29.0
Total	0.3	2.8	8.5	599.5	3.3	209.5	0.2	--	0.3	9.5	71.3	151.0

Table 1. Summary of Chemical Stock in Laboratories

not counted in the estimates given on Table 1. Storage practices were worse here than anywhere else. For example, most of the unknown compounds were stored in fume hoods (see Principles of Safe Storage in the Section Introduction). The significant hazards include 27.0 liters of Flammable liquid and 29.0 liters of Other liquids. None of the Flammable liquids were stored in a flammable storage cabinet.

Discussion

Recommendations for proper storage must not only account for chemical stocks, safe storage principles, space availability, and needs of investigators, but also anticipate future uses of the laboratory. Input from those concerned with lab safety helps ensure that a correct decision is made. Information about chemical amounts gives an indication of the kinds and number of storage facilities needed. Knowledge of room structure helps resolve how storage facilities can be arranged. Observation indicates potential problem areas.

Of the eight academic laboratories studied, there are three different types of labs. Laboratories such as Room G, for example, tend to have a large variety of chemicals (in small amounts) stored in laboratory cabinets. These labs, which are small and not used extensively, need improvement in separating what few hazardous compounds exist. Because of the low amounts, unfinished kitchen cabinets (which may be finished by hand) are probably the most prudent because of their lower cost over ordinary laboratory cabinets. However, "before making a price comparison, the planner should determine the cost of finishing, which could be considerable" (Rosenlund, 1987). For Room G, the present storage facilities suffice, although further separation of hazard types by barrier inside each cabinet might be appropriate. General air circulation in this lab seems to be adequate.

Room D is typical of a lab having a small variety of chemicals but in large amounts. This lab is small and used extensively, but storage was adequate because of the extra precautions taken by the investigator. The large amount of Corrosive liquids indicates that at least two separate storage cabinets will be needed (each with plastic trays to contain accidental losses). For the other types of chemicals, about five general storage cabinets should be installed (kitchen cabinets will suffice). The general air circulation seems sufficient. Note that Room D is not in compliance with regulations set by the State Fire Marshal's office. Room D contains an estimated 150 liters (or 37 gallons) of t-butyl alcohol, a Flammable liquid. Because Berkeley labs are limited to 20 gallons of flammables stored outside a flammable storage cabinet, it will be necessary to store at least 17 gallons (but preferably more) in a flammable storage cabinet.

Room B is the same as Room D in that it also holds a small variety of hazardous chemicals in large amounts, is small in size, and is in violation of storage regulations. Even though Room B is not used extensively, this lab needs to eliminate the large volume of chemicals. A fume hood should be installed so that acid uses are more completely controlled. Storage space for over 550 liters of corrosive chemicals – in four 55-gallon drums – should be set aside if such large amounts are absolutely necessary. Otherwise, safety, and not economic benefit, is the important consideration. The observation that the drums were corroding on the outside suggests it is time to dispose of these chemicals.

A lab such as Room H contains a large variety of chemicals in moderate amounts. This lab, which is moderately large and not used extensively, needs to deal with both separating chemicals of different hazard classes and finding space to place the large number of cabinets that would be needed. Because storage was not adequate, and because of the large amount of chemicals found, this lab needs to set up an inventory system. Personnel will have to sift through and separate those chemicals which can be identified. Unknown chemicals should be disposed of in the appropriate manner.

Conclusion

Establishing a safe chemical storage area is not difficult if it is approached methodically. Because current legislation does not require use of safe storage principles, many may feel that such effort is too expensive or too troublesome for the benefits received. There are several reasons why this is not true.

The most obvious reason is a safe laboratory. This factor cannot be overemphasized because the potential for expensive injury claims exists. But other reasons, such as increased efficiency and increased savings from over-ordering chemicals are just as important. And if regulations in the future require safe storage principles be used, the extra dollar spent today could result in considerably higher savings tomorrow.

The fact remains, however, that chemical storage regulations allow room for personal interpretation. As a consequence, unsafe storage practices exist on the campus. As a university agency responsible for maintaining a safe chemical environment, EH&S does offer advice on chemical storage, but it is left to individual departments to determine their storage needs. (Universities wanting interpretaion of regulations may have to look to outside sources if such offices as EH&S do not exist on campus.)

The problem in allowing departments a wide latitude in their control of storage areas is that safe storage principles are often unused. The reasons for this vary from little knowledge of the safety principles to little desire to use such measures. Yet it is significant that emphasis on safe storage practices in some academic laboratories has been dangerously lacking in the past.

Eventually, departments will realize that safe storage of hazardous chemicals makes sense. Some departments, in fact, already understand that safe storage is logical – the cooperation of laboratories on the campus for this report is testimony to this fact. Realizing that dangerous products may form when chemicals of differing hazard classes are accidentally mixed is only half the problem. An application of effort by all concerned is essential in obtaining and maintaining a safe storage environment.

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