Introduction

The storage and use of chemicals in industry is subject to a number of pieces of legislation that are designed or intended to ensure the safety of workers, the prevention of pollution to air or waterways, the prevention of accidents due to incorrect storage and mixing of chemicals and the general safety of the general public. Examples are the Environment Protection Act and the Dangerous Goods (Storage and Handling) Regulations. Legislation includes the Hazardous Substances Regulations, which are designed to bridge the gap between the storage and transport of hazardous goods, and the actual working with and handling of dangerous goods to reduce risks of exposure to certain chemicals.Dangerous goods can be said to present an immediate danger while Hazardous Substances may present a danger over a prolonged or delayed time period. There are no Acts or Regulations in place that apply specifically to laboratories, only guidelines and standards that individual organisations have initiated such as the Department of Education or Standards Australia, or training courses such as this one. Laboratories are exempt from the Dangerous Goods (Storage and Handling) Regulations.

Laboratories have special problems not normally encountered in industry. They are smaller, have little or no dedicated storage areas, usually contain a huge number of different chemicals of various classes, generate many types of chemical waste and because there is no controlling regulation on safe and appropriate storage of chemicals, little incentive other than that generated from within to comply with accepted good practice and housekeeping. In other words, any initiative to get laboratory up to scratch as far as safety and risk usually comes from within, usually by the workers in the laboratory.

The following points are mandatory in maximising your safety while working in the lab and the safety of your fellow workers and visitors. They are the basis for good chemical management. The points will be expanded on later.

1. Correct Storage of Chemicals. This is done by following the Dangerous Goods Class system that applies to chemicals that have properties, either chemical or physical, that places them into one of nine hazardous classes. The class system provides compatibility rules between the classes to minimise unwanted reactions should two incompatible classes come into contact. The hazardous system also provides rules for safe transport and storage of dangerous goods.

2. Knowledge of Chemicals and their Properties. It is essential to become familiar with the properties of certain of the chemicals within your chemical store. What makes some chemicals belong to a particular hazardous class? Where do the so called non hazardous chemicals fit in?

3. Information Sources. Where do you obtain information on chemicals, their properties, special things to look out for etc.

4. How to Segregate Chemicals in a Single Store. How can you safely store two incompatible classes within the same small chemical store.

5. Keep Stocks To a Minimum.

6. Good Housekeeping. This includes keeping accurate inventories, having spill kits and clean up materials, fire extinguishers of an appropriate type etc. It is mandatory under Hazardous Substances regulations for you to maintain a manifest of hazardous substances and it is certainly a good idea to have an overall manifest of all chemicals in the laboratory or workplace

7. Using Appropriate Materials for Storage, Shelving etc.

8. Waste Disposal. Before waste can be disposed of it must usually be stored and in most cases a dedicated waste store is a luxury these days, so is usually stored in the chemical store.

1. Correct Storage of Chemical.

The Dangerous Goods Class system of classifying chemicals that have certain properties is a system universally used and recognised. Only chemicals that have been classified into a Dangerous Goods class are by definition "Dangerous Goods". They will also be assigned a UN (United Nations) number, a packaging group and in some cases a Hazchem code. A non hazardous chemical is one that does not have any of the properties of one of the nine Dangerous Goods classes and the rules of compatibility and segregation do not apply. The properties of dangerous goods range from being explosive, flammable, poisonous causing death by ingestion, infectious, corrosive, radioactive, oxidising, spontaneously combustible, dangerous when wet, etc. Because of some of these properties, it becomes apparent that certain chemicals should be stored in a fire proof environment, or under lock and key or protected from water or heat. The class of the chemical will tell you what the problem is with the particular chemical at a basic level without going into any specific dangers. For example, ethanol is a flammable liquid because it has a flash point of less than 61EC., and is therefore. a class 3. This is enough information to enable you to store ethanol in a flame proof cabinet or fire proof store. Methanol is also a class 3 chemical but it is also much more poisonous than ethanol. Methanol is a primary class 6 (toxic) and secondary class 3. The fact that it is a class 3 is still enough to tell you where and under what conditions to store the methanol and the extra information that is has a primary risk of class 6 (poison) is only of use to you if you wish to keep the stocks of poisons to a minimum for example or restrict its use to the experienced. The class of a chemical if any, at a simple level, is usually all you need to know. Segregation and compatibilities will be discussed in point **4.** But you will still require a working knowledge of the class system to enable you to store different classes that are incompatible with each other in the same store, with safety.

2. Knowledge of Chemicals and Their Properties.

The class of a chemical if any is the first step. Specific knowledge comes next and it is an excellent idea to familiarize yourself with specific information about specific chemicals. Good examples are found in the class 4.3(dangerous when wet) chemicals. Common examples are sodium metal, potassium metal, zinc dust, sodium borohydride, calcium carbide. This class must obviously be stored where there is no danger of coming into contact with water, but why? Sodium reacts vigorously with water emitting hydrogen and forming sodium hydroxide, so a flammable gas is formed and a corrosive liquid results. Potassium also reacts very vigorously with water with emission of hydrogen but the heat of reaction is such that the hydrogen catches fire. So we have potentially got a flammable gas fire (and potassium hydroxide solution).

Zinc dust added to water does very little however if a little water is added to a mass of zinc dust the zinc will become very hot to the point of glowing red hot. Aluminium powder is also a class 4.3 and if water is added to it glowing occurs followed by vigorous burning and sparks. Sodium borohydride emits hydrogen when wet and may even catch fire if old material is suddenly exposed to cool air. Calcium carbide when wet emits acetylene, a gas more flammable than hydrogen and heavier so that it sinks and remains close to the source. The acetylene does not catch fire but it easily ignited. All these examples show that while they are all class 4.3, dangerous when wet, the actual reaction and resulting products are not all the same. This sort of knowledge will assist you in planning spill and evacuation procedures, locations in the store, and the likely outcomes from accidents involving water with these chemicals.

3. Information Sources.

Where doe you obtain information regarding a chemicals class and any dangers or reaction specific to it? An excellent source of information available for free are the laboratory chemical companies catalogues such as the Ajax Chemicals Fine Chemicals Reference Manual, also available on disk which comes with the manual. Merck/BDH also produce a similar volume, also for free. The publication Australian Code For Transport of Dangerous Goods by Road and Rail,current edition is the 6th, available from Government bookshops is the reference of choice for transporters and storers of dangerous goods at an industrial level but the same rules will also apply when scaled down to the laboratory. Merck also have MSDS generating software that has details of over 8000 laboratory chemicals including all safety and risk exposure information. This is not free but is one of the first systems for generating full material safety data sheets for laboratory chemicals. Specific information is also available from Merck Index which is priced modestly and from Bretherwick, Handbook of Reactive Chemical Hazards and Hazards in the Chemical Laboratory (available on CD-ROM), published by Butterworths. A good chemical dictionary is Hawleys Condensed Chemical Dictionary. We suggest you use a range of sources. Bretherwick also has plenty of example of previous accidents involving dangerous goods. The section on aluminium powder is particularly lengthy! When you purchase a chemical that is also on the Hazardous Substances list then it is mandatory for the supplier to provide a current material safety data sheet. The msds can then be added to your chemical manifest or msds manifest, and is an excellent source of information. Commercial suppliers of msds are also available such as Safety Label Pro, ACOHS etc.

4. Segregation and Compatibility.

One of the main reasons the hazardous class system was incorporated was to minimise the risk of reactions from two different hazardous classed chemicals. It will become apparent that many of the classes should not be allowed to come into contact with each other and indeed warnings to this effect appear on many chemical bottles, for example the warning on class 5.1 oxidisers, is to avoid contact with combustible or flammable materials and sometimes even organic materials. The types of reactions that can occur include fire, explosion, emission of flammable or poisonous gases, emission of hot or corrosive acid or alkaline liquids etc. A compatibility chart is enclosed with these notes. Use the chart to work out whether or not any two classes are compatible. If they are, then they can be stored together in a laboratory chemical store because if they are allowed to come into contact by way of accident or spill, then little or no

reaction producing any of the above results will occur. If the two classes in question are not compatible then they should not be stored together otherwise an unwanted reaction will occur. "Should not be stored together" is used because laboratories are exempt from dangerous goods requirements storage regulations, but it should be obvious that it is an excellent idea for you to comply.

In a factory the dangerous goods of certain classes must be stored from one to five metres apart or in separate buildings in some cases. Segregation in a factory is achieved by distance. In a laboratory segregation is also achieved by distance but in between the two incompatible classes can be stored the non hazardous items. Because they are non hazardous then the segregation rules do not apply. The non hazardous chemicals are said to be buffer chemicals between two incompatible classes. In practice it is strongly recommended that the separation distance between any class 5 chemicals and class 3 materials or non hazardous organic materials such as paraffin oil or waxes be kept at a maximum. These two incompatible classes have the potential if mixed to cause at the least fire and at worst explosions. In fact any organic material including the examples above should not be stored near oxidisers and you may even consider separate storage for one or both classes. For example a flammable liquids cabinet to provide further segregation. Chemicals of the same class are often incompatible, the most common example being acids and alkalis, both are class 8 corrosives but must not to be stored together. If mixed, these two types of chemicals usually produce a vigorous reaction accompanied by steam, gas and corrosive fumes. Again store at opposite ends of the store or have one in a purpose built cabinet to provide extra segregation. Class 8 and class 6 chemicals are seen to be compatible except where the class 8 is a mineral acid and the class 6 is a cyanide. If mixed these two produce the deadly hydrocyanic acid gas (the active ingredient in American gas chambers) Class 5.1 and 5.2 (organic peroxides) are also incompatible so store these away from each other. Organic peroxides such as benzoyl peroxide or lauroyl peroxide or methyl ethyl ketone peroxide are also to be stored as the 5.1 chemicals ie. away from flammable liquids and organic materials. The solid peroxides should usually be stored wetted as they become explosive when dry and can be set off by heat.

Sitting two incompatible classes of chemicals side by side is not going to actually do anything, it is only when they come into contact. This can happen because of leaks or spills, breakages or in extreme cases physical causes such as fire or the collapse of a shelf. We attended a laboratory that had a shelf fall off a wall. The shelf was holding many reagents and chemicals in a lab at a Department of Agriculture Veterinary Research Institute. Apparently there was an emission of pungent gas and the room filled with fumes. No one really knew what had been on the shelf and three technicians were told to go into the lab to clean up the mess on the floor. They were all affected by the fumes and one lady actually suffered respiratory damage. When we attended to remove the spill clean up materials for disposal there were still unbroken bottles and flasks on the floor including a bottle of potassium dichromate (class 5.1) and ethanol (class 3). These are incompatible and should not have been on the same shelf as almost definitely a fire would have resulted to add to the other reactions. The accident was just that, an accident, but they do occur and when you least expect them and for the stupidest reasons. The storage of chemicals and reagents on shelves must also be subject to the same segregation and compatibility rules that apply to your store. The storage of goods on an overhead shelf is not a good idea unless the shelf is bunded or protected. You must consider the worst case scenario and ask yourself what would happen if the chemicals on that shelf were to all be mixed together. Also keep in mind that a laboratory is a workplace not a store, so try to keep stocks of chemicals especially the ones that potentially cause the most damage in an accident in the store, and bring them out for use but replace them after.

5. Keep Stocks to a Minimum

Keeping your stocks of hazardous chemicals to a minimum is plain common sense. The results of a fire involving large amounts of flammable liquids are much worse than one a small fire that can probably be put out quickly on the spot. If a 200 litre drum of acetic acid or alcohol were to rupture or leak then the resulting spill is a major one compared with a winchester of the same materials breaking. 200 litre drums in a store must be kept on a bunded container like a large tray or in a bunded store where there is no likelihood of the material escaping. Most warehouse fires involving dangerous goods in Melbourne in years past were very serious because of incompatible dangerous goods coming into contact while being stored without any reference to dangerous goods rules. The Butlers and United Transport warehouse fires caused the Hazchem system of placarding to be introduced into Victoria and also caused a complete rewrite of storage and handling regulations for dangerous goods. The Coode Island fire was an example of what can happen when large volumes are involved. There was no incompatible storage at Coode Island just a breakdown in emergency procedures and systems and some inexperience on the part of some of the emergency services. A laboratory store is different of course but no one would want a fire in a laboratory or the store. Keeping your stocks down also enables you to keep track of what is in the store and to work out what is not longer required or a slow mover. This can be difficult if the store is full.

6. Good Housekeeping

Good housekeeping practices include having a good inventory of chemical stocks, having special knowledge of problem chemicals, having appropriate clean up procedures and disposal systems, having appropriate safety equipment as well as keeping the store and laboratory clean and tidy. The chemical inventory is essential as ageing and slow moving stocks and surplus items can be identified as well as old materials that may deteriorate in time. You can't apply the segregation rules unless you know what you've got, and you need to know what you've got to comply with Hazardous Substances regulations anyway.

Clean up procedures in the event of a spill include having the correct absorbents and neutralisers and containers for storing the spill materials ready and available, before disposal can occur. The proprietary kits available from chemical suppliers are usually expensive and for single use and generally consist of an absorbent/neutraliser with gloves, glasses, plastic bags etc. All of this equipment will probably be in the lab anyway. The best all round absorbent to use is vermiculite which is non reactive with any chemical we have come across. It can be made more specific for acid spills for example by the addition of soda ash, for ammonia spills by the addition of citric acid. The choice of absorbent is simply based on what chemical you are trying to absorb. Vermiculite is appropriate for just about any liquid. Solid spills are in most cases simply swept up and containerised, keeping in mind at all times that the waste materials have the same properties as the pristine material. Flammable liquid waste is still a class 3 material. Being waste material doesn't change its hazardous properties. Don't neglect to label your waste. This is commonly overlooked. Terms like organic waste and solvent are not good enough.

Safety equipment includes gloves and glasses and lab coats and should all be appropriate to the chemicals you are handling. The use of rubber gloves with some solvents is not appropriate for example, and latex gloves are not chemically impervious at all. Use neoprene or pvc.

Special problem chemicals include things like hydrofluoric acid, white or yellow phosphorous, concentrated formic acid, ethidium bromide, perchloric acid, ethers and furans that form peroxides, hydrogen peroxide, picric acid, 2,4 dinitro phenylhydrazine, calcium hypochlorite, ammonium dichromate, organic peroxides etc. If you are using any of these your information sources should provide you with with special precautions. Don't forget, not all chemicals are toxic or dangerous. Be specific: what chemical is involved in the spill or incident.

Being clean and tidy in a lab is often a thankless task but having special bins for glass, paper and general waste is essential. These are all chemical wastes to be disposed of appropriately.

7. Materials for Storage Systems

The material your flammable cabinet of corrosive cabinet should be appropriate for the material you are storing. Placing acids into a class 3 cabinet is not a good idea as the flammable cabinets are metal as well as being expensive. Acids must be in acid proof surroundings as one of the problems with strong mineral acids is the corrosive vapours. The use of two part epoxy acid proof paints to line a wooden cupboard is a good idea but such a cupboard must also be bunded to prevent escape or any leaking liquids. Use a plastic tray for example. Any dangerous when wet chemical must be protected from potential sources of water, so don't store in an area with water sprinklers, or next to a sink for example. Storing dangerous goods on an overhead shelf should be carefully looked at considering the example at the Dept of Ag lab. Overhead storage also has the potential to cause spillage as you take an item down because someone hasn't replaced the cap or stopper. A bund to prevent leaks from dripping onto the bench below should be considered and the material of construction of the shelf must be chosen carefully. This applies to any shelf or cupboard. Alphabetical storage is also not appropriate these days. Store according to class

8. Waste Disposal

Waste materials include materials generated by the normal work of the laboratory such as the ubiquitous solvent wastes, as well as old and surplus materials, degraded chemicals and materials from a spill or clean up. Glass and wipes are also chemical wastes, The physical and chemicals properties of chemical waste are such that they are still usually dangerous goods and therefore the same rules of segregation and storage apply. If you do not have a dedicated chemical waste store and must use your existing chemical store then the same rules apply. The waste should be considered just another chemical with a hazardous class if any, like any other chemical. The two biggest problems with chemical waste generated from laboratories is inappropriate storage and bad labelling. Chlorinated solvent wastes should not be stored in metal drums that previously contained non chlorinated solvents. They are usually corrosive to metals because of free chlorides. Use a second hand chlorinated solvent drums or plastic carboys. The drums used for new chlorinated solvents are lined and therefore impervious to corrosion. The use of glass containers like old winchesters is generally not appropriate. We prefer the plastic carboy for consolidation of solvents, always keeping chlorinateds apart from non chlorinateds. Radioactive waste should not be put into biomedical bags. Low level radioactive waste is disposed of by special landfill and bags that look like infectious waste will be refused entry to the tip. Be aware of shielding requirements for radioactive sources if you have them . Lead sheet is not always appropriate. Labelling is a very neglected area of responsible waste disposal. The label is to inform anyone at all without ambiguity what is in a chemical container. Do not use formulae alone as not everyone

can read them. Use concentrations for strong acid wastes. List the solvents for organic solutions and indicators. ”

Try to avoid using amusing labels like “This is Stuffed” or “Complete Shit” or “?” or “Potassium Something” for example. We do not laugh at such labels when we are trying to determine what the waste is. We always charge higher for unlabelled wastes.

Summary

The safe management and handling of chemicals in the laboratory is based on knowledge, knowledge of the chemicals you are dealing with. There is no other way to safely handle them but at the very basic level a knowledge of the chemical class if any of the chemical is the most important starting point. Not all chemicals are dangerous or hazardous and they do not all have the same properties. Acquaint yourself with the properties and dangers of the chemicals you are dealing with and take the appropriate steps. Be proactive in your planning for safety because accidents are bound to occur. School laboratories are generally populated by inexperienced students who may be in a laboratory for the first time. It all new to them so please keep this in mind.