



## Online Chemistry Course (OLCC)

# Chemical Safety: Protecting Ourselves And Our Environment

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**Laboratory Emergency Response:  
Preparing for Common Laboratory Emergencies**

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## **Introduction**

Regardless of the workplace, emergencies *will* occur. Laboratories, even well controlled, academic teaching laboratories are not immune to accidents and emergencies. Whether by carelessness or naivety, or by way of “unforeseen circumstances” such as a loss of electrical power or site cooling water, it is a good bet that every chemist will eventually experience an emergency sometime during his or her career.

Fortunately, the variety of “catastrophic” emergencies that chemists may experience is rather few in number. By far, the most common laboratory emergencies are:

- Fires and explosions (with or without chemical spills)
- Chemical spills (with or without personnel overexposure)

Less common emergencies include such occurrences as thermal or electrical burns or cuts by glassware. While those emergencies are sometimes bloody and painful, this OLCC section will concentrate first on the prevention of fires/explosions and spills, then actions that should be taken to mitigate common emergencies.

### **Prevention is the place to start**

Certainly, it is always better to *prevent* emergencies from occurring. Hundreds of “work rules” or administrative controls are contained in literally hundreds of thousands of safety plans to prevent accidents from occurring or, worse, re-occurring. Some work better than others, and the ones that I find most useful, and more importantly; *ones that will be heeded* contain few words and a great deal of common sense. From SACL<sup>1</sup>:

- Follow all safety instructions carefully.
- Never play tricks or indulge in horseplay in a chemical laboratory.

- *Before undertaking any laboratory work, become familiar with the hazards of the chemicals involved. Be sure you know and be sure you follow the safety precautions that protect you and others from those hazards.* (Emphasis mine).
- *Become familiar with the hazards of the apparatus and operations involved. Learn what to do and what to avoid doing. Follow these safety precautions.* (Emphasis mine).

Most all administrative controls for chemical work come from the two fundamental principles emphasized above, which can be distilled even further: Know *what* your working with and *how* to work with it safely. The rest are simply “motherhood” statements.

So, is it that simple? Know what I’m working with and how to work with it safely? What does “knowing what I’m working with,” mean? Well, it means in part:

- Knowing the hazardous characteristics of *all* chemicals being used: Are they corrosive? Flammable? Oxidizers? Lachrymators? Sensitizer? What is the toxicology of the compound? What is the reaction “profiles” of the compounds being used? A material safety data sheet (MSDS) will provide many of the answers to these questions. That is the *first* place to look for information on your chemical, but certainly not the *only* place to the information. Other sources of information include, but are not limited to:
  - Laboratory Chemical Safety Summaries, located in *Prudent Practices*.
  - A quality reference work, such as the *Merck Index*.
  - **Peer reviewed** toxicological works such as *Patty’s Toxicology*.

- Chemical Laboratory Information Profiles, CLIPs, found in the Journal of Chemical Education.
- What is my anticipated reaction? Is it endothermic or exothermic? Do I need to remove heat and, more importantly, ***am I able to remove heat rapidly enough to prevent an unwanted or uncontrolled (better, uncontrollable) temperature or pressure excursion? (Do I have the ability to rapidly quench an undesired excursion?)*** Does the order of reagent addition matter to the chemistry? What will happen if it isn't correct? What if I lose power or services such as cooling water to my experiment? Will it fail safe?
- What happens if I screw up?
- Am I familiar enough with the apparatus used in an experiment to use it safely? Is the apparatus in good working order? (Valves move freely, secure electrical connections, controls are functioning as they should, switches are not corroded, etc.)

Designing fail-safe experiments is not as difficult today as it was twenty or thirty years ago. There are a number of ways to monitor reaction vessels for temperature and pressure and control reagent addition via computer or by hand. Likewise, services such as electricity and cooling water can be monitored using appropriate instrumentation. By combining “old” technology such as the “Jack-O-Matic” (Figure 1), with microprocessor controls monitoring critical reactions parameters (such as reaction temperature and pressure), and vital service parameters (such as water flow or voltage) reactions can be well controlled.



**Figure 1: The Jack-O-Matic is a pneumatic jack that is controlled via a thermocouple device (not shown). It is a product of I2-R.**

Over the last few decades, the “less is better” philosophy has seen a great advancement in the profession. When speaking of “less is better,” we normally turn to waste management issues and chemical inventory issues. However, the philosophy also finds a great deal of application in emergency management and preventing chemical spills that cannot be easily cleaned up by laboratory personnel. *There is no better way to prevent a large spill than to limit the quantity of chemicals with which one is working.*

Second to limiting the quantity of chemicals in the prevention of large-scale spills is to provide adequate containment around reagents and experimental apparatus so as to limit the spread of the spill once it occurs. Secondary containment devices such as trays and tubs, and the now readily available plastic-coated glass bottles significantly limit the spread of spilled chemicals.

## **So, I didn't prevent it...now what?**

### ***Reacting to an emergency***

Before you need to react...*train!* The experience that is gained during training in mock incidents is invaluable. It will allow you to ascertain your strengths and weaknesses in a simulated emergency. Training for fires and spills should start with simple scenarios and then, as time allows, grow to more complex emergencies that include contaminated co-workers and large-scale fires and spills.

We have all experienced emergencies in our lives. The very first reaction and thought we think is, "I must *do something*." It is ingrained in our nature from birth; thinking we must *do something* has become a conditioned response, done automatically, practically without thought. We need to suppress the thought and the associated emotion if we are to successfully overcome the emergency. Unfortunately, many chemical workers do not practice emergency response often enough to suppress the initial action of "panic."

*Before* reacting to an emergency two very important questions must first be answered. The two questions are:

1. What am I doing?
2. Why am I doing it?

Failing to have a sufficiently good answer to these two fundamental questions can lead to larger emergencies and even fatalities in some instances<sup>2</sup>. As one fire chief I know stated, "All fires eventually go out and all bleeding eventually stops<sup>3</sup>." Remember, doing "nothing" might be the best course of action in some emergencies. If you cannot provide an answer to these questions, get help!

### ***Explosions and Fires***

**Before you act, remember: All fires eventually go out. There is nothing in your lab that is worth your life.**

All laboratory personnel should be familiar with the guidelines presented in *Prudent Practices* section 5.C.11.9<sup>4</sup>. Notable guidelines paraphrased from that section include:

- Know the locations for all fire extinguishers in the laboratory and other workspaces. Insist to management that the fire extinguishers in the lab are compatible with the experiments performed in the laboratory. A photograph of various types of fire extinguishers is found in figure 2.
- Extinguish small fires only if you're confident you can do so both successfully and quickly, and from a position that allows you to run if the fire gets out of hand. Keep in mind toxic combustion products will present hazards (and associated risk) in addition to the fire alone.
- Reactive metal and organometallic fires are difficult to extinguish. Make sure you have the right material such as sand or a commercially available product for these fires. Class "D" fire extinguishers are very expensive and rare, especially at smaller colleges and universities. Sand is sometimes substituted for a class "D" extinguisher, but it does require you to get closer to the fire.
- If in doubt...leave and evacuate the area using the fire alarm.
- If called, let the fire department know important information such as the location of the fire and the hazardous chemicals in the laboratory.

**Insist** that your EH&S department conduct routine fire extinguisher training and learn from it. Keep in mind, however that this type of training is conducted under the most highly controlled circumstances. Dropping and breaking a four-liter container of solvents will cover an area up to 40 square feet, which, when ignited will present quite a challenge for a 15-lb carbon-dioxide fire extinguisher. *Before*

***you act, remember: All fires eventually go out. There is nothing in your lab that is worth your life. (The redundancy is intentional!)***

Fires and explosions often result in damage outside of the fire and associated water damage. More likely than not, chemical spills will accompany a laboratory fire.



**Figure 2: Various types of portable fire extinguishers.**

### ***Chemical Spills (with and without contaminated personnel)***

What is a spill? Simply put, a spill is a chemical that is out of the control of the user. A few drops here, a couple of crystals there or dropping a full two-and-a-half liter container of your favorite acid all result in the same thing: A chemical out of control. The only question is the quantity. In the case of chemical spills, this quantity will dictate, at least in part, the response effort that is directed at cleaning up the spill.

What is your “comfort level” in cleaning up a spill? I have found (through experience) that the largest quantity that most laboratory chemists are comfortable with cleaning up is about one liter. This quantity is, of course, dependent on the chemical real or perceived toxicology, and is not meant to be a dividing line between “large” and “small” spills or when a Hazardous Materials Emergency

Response Team should or should not be called for help. Each organization needs to make that decision on their own with their own personnel. However, the “less is better” idea really applies when it comes to chemical spill management. Keep the quantities small so that the bench chemists can clean up their own messes!

*The Hazmat Team Controversy – Do I Need a Hazmat Team? Do I Want one?*

A Hazardous Materials Emergency Response Team (Hazmat Team) is clearly not *required* by the OSHA standard governing the use of emergency response teams, 29 CFR 1910.120<sup>5</sup>. Two options are open for organizations that use hazardous materials to avoid creating a Hazmat team:

- Your agency’s emergency response plan dictates that the area is to be evacuated and cleaned up by someone else. (29 CFR 1910.120(q)(1).)
- You *limit the quantity* of chemicals such that **any release** is deemed “incidental” in nature such that employees can control it. (29 CFR 1910.120(a)(3), definition of “Emergency Response”). Less is certainly better now!

There are a number of very good arguments both for and against creating a Hazmat Team for an organization. Some arguments for creating a team include<sup>6</sup>:

- Compliance with organizational policy
- Organizational credibility
- Societal expectations
- Expertise tailored to your facility

While the arguments against creating a Hazmat Team are equally valid<sup>7</sup>:

- Probability of a severe release vs. cost of creating and maintaining a team
- Many local fire departments have one that is available for university response

- Personnel issues:
  - Can an adequate level of expertise be obtained with the current employee base?
  - Will current job descriptions need to be modified? What about “on-call” issues, hazard pay adjustments.
  - Is the proper level of supervision available?
  - Can the organization live with lost staff time because of an injury during training or response?

In case there is any doubt, let me emphatically state that creating and maintaining a Hazmat Team is an expensive proposition. At least \$5000-\$7500 *per person* in initial training and equipment costs will be required, with additional annual expenses<sup>8</sup>. If your organization cannot commit to that minimum level of fiscal support, don't create one.

*How big is too big?*

When do you need to call in the professionals? When does a chemical spill become “too big?” That all depends on the comfort level your workers have in managing emergencies in general and chemical spills specifically. Organizations may establish guidelines regarding chemical releases, only to find themselves on 6:00 PM news for what was a minor event. Generally speaking, a spill becomes too big to handle and professional help is needed if:

- The spill involves multiple floors of a building; or
- The spill cannot be managed by the staff in the laboratory; or,
- The spill cannot be managed without the use of specialized PPE (e.g. respirators) which laboratory workers have not been properly trained or certified to use. Examples include compounds of extreme toxicity, lachrymators, severe irritants and sensitizers; or

- The material is sufficiently volatile that it will cause multiple areas to be evacuated or reach unacceptable airborne concentrations in the laboratory (this is a corollary to the point above) ; or,
- The spill is “outside the comfort zone” of the workers in the lab. (“I don’t think I can handle this one...”). (Note: This is intentionally nebulous. The last thing you need during spill clean up is for someone to get hurt. It is better to call in pros and risk the 6:00 PM news than to make the spill worse.)

#### *Cleaning up the generic spill – SWIM*

*Prudent Practices* gives some very general guidelines to follow for spill containment and cleanup in sections 5.C.11.5 and 5.C.11.6<sup>4</sup>. Generally speaking, all facilities where hazardous chemicals are handled should have materials on hand and ready-to-use to clean up incidental spills. Those materials must be completely compatible with the material that is spilled in order to prevent unwanted reactions. Inert absorbent materials are commercially available through any of the large chemical supply firms.

Personal Protective Equipment (PPE) should also be in ready supply near a spill kit. At a minimum, a laboratory coat, gloves (compatible with the spilled material), and chemical protective goggles should be used. Additional PPE, such as chemical protective coveralls, face shields (used in conjunction with goggles) and respirators may also be required. A “generic” spill kit is featured in figure 3.



**Figure 3: Generic spill kit. Kit includes absorbents, goggles, litmus, a neutralizer, gloves, and waste bags. The bucket can be used for lab packing.**

Spill clean-up training need to occur on a regular and on-going basis. When training for spill management, keep the steps simple and easy to remember. I like to use the acronym SWIM<sup>2</sup>:

- **S – Stop the spill.** Stopping the source may be as simple as placing an intact bottle upright. In many instances, particularly in chemical laboratories, the source of the spill will be “stopped” once a bottle reaches the floor or the bench top. However, in larger facilities or in scale-up laboratories, stopping the spill may include closing valves or other shut-off devices.
- **W – Warn Others.** Warn others in the area so that they can lend a hand with the cleanup if necessary and prevent contamination spread either to their person or throughout the facility.
- **I – Isolate the Area.** Use barrier signs, ropes, furniture or other items to restrict traffic through the area. If possible, use an announcing system to let

others in the building to stay out while the clean-up continues. Be careful! A spill will *probably* cover more area than it immediately appears. Look for signs such as broken glass shards and droplets to find the extent of the spill, and isolate an area large enough to contain the spill and work in.

- **M – Minimize exposure during cleanup.** Use proper PPE and verify the cleanup method does not create a more hazardous product than the one that was originally spilled. Proper PPE means *proper for the material that was released*. Insure that cleanup materials are properly labeled and disposed. Work from the outside of the isolated area, in toward the center of the spill. After cleanup, decontaminate the area using a neutralizing solution or soap and water. Finally, check the surfaces for residual contamination. (e.g. use litmus dampened with deionized water to check for acid/base residue. If it the litmus changes color, decontaminate and check again.)

#### *Spills resulting in personnel contamination and/or injury*

The treatment of an injured or contaminated co-work clearly takes precedence over the spill for most situations. First aid followed by prompt and effective medical intervention can often mean the difference between the inconvenience of missing a few days at work and a permanent disability. All laboratory workers should be familiar with self-aid and first aid in the event of a chemical overexposure. General first aid guidelines are presented in section 5.C.11.4 of *Prudent Practices*<sup>4</sup>. For spills on the skin:

- Flush the affected area for at least 15 minutes with tepid water.
- If there is no visible “burn” wash the affected area with a mild soap and warm water. Remove any jewelry before washing.
- Check toxicological reference material to see if any delayed effects are expected. (Note, this level of information may not be present on an MSDS.)
- Seek medical attention even for minor chemical exposures.

Large chemical exposures require the use of a safety shower to flush chemicals off the body. Emphasize to workers that safety equipment is there to be used, and modesty really does not matter when it comes to chemical exposure<sup>4</sup>. If the chemical exposure is sufficiently large to require the use of a safety shower, be careful not to spread the chemical to uncontaminated parts of the body and it may be better to cut clothing away from the body rather than try to pull it off. Make it an organizational policy that medical intervention is *required* if the shower is activated for use.

Eye exposure can be particularly nasty and **is a medical emergency**. *Prudent Practices* gives some first aid guidelines for chemical splashes to the eye. I would like to emphasize that it will probably take at least one other person to assist the injured co-worker flushing the eyes to hold the eyelids open and to insure the eyes are being flushed. Notify Emergency Medical Services (EMS) that the injured worker has an eye exposure and insure they, in turn, have an ophthalmologist ready at the Emergency Room.

After the first aid is given and the injured transported to an Emergency Room, clean up of the spill can begin.

A general word of caution is in order when using a safety shower or eyewash. The amount of water that is used is tremendous. (In the case of a safety shower, 40 gpm!) Floors *will* get wet; and waxed, tile floors will get very slippery when either device is activated. Many institutions do not have floor drains for their emergency wash equipment, so activating the system will create a very large spill. Albeit it is will be primarily water, there will be a lot of it. I strongly urge the use of non-skid adhesive strips in the areas surrounding eyewashes and safety showers.

***Maintaining Emergency Equipment – You get what you inspect, not what you expect.***

Emergency equipment is seldom used and rarely a thought is given to it...until it must be used. Then it needs to work correctly the first time.

Throughout this presentation, we've discussed several emergency equipment items: Fire extinguishers, spill kits, emergency showers and eyewashes. All of these items need to be inspected on a regular basis in order to insure they will function properly when the need arises. While this kind of housekeeping may seem mundane and unimportant, I cannot overemphasize its importance to a viable safety program. Simply put, emergency equipment must function as intended, the first time, *every time!*

A preventative maintenance system (PM system) needs to be established for emergency equipment within every organization working with hazardous materials. A PM system, in part, will identify critical equipment and inspection frequency to insure the equipment is available for use.

Fire extinguishers should be inspected at least monthly to see that they have not been used or have lost pressure (if a gage is supplied.) Many local fire districts require an annual inspection by a certified or licensed professional as well.

Spill kits should be filled, then sealed with a commercially available, easily breakable seal. Inspection then becomes a matter of noting if the seal has been broken, and if so, taking inventory of the kit. Unsealed spill kits become an easy "replacement bin" for gloves, goggles and spill pads.

There has been a lot of discussion on the various safety-related list-serves regarding maintenance of eyewashes and safety showers. ANSI Z358.1 (current edition) provides definitive guidance regarding the activation of eyewashes and showers for maintenance. Regardless if your organization follows the recommended guidance from ANSI, plumbed eyewashes and showers need to be flushed at least weekly in order to curtail microbial growth in the pipes<sup>9</sup>. Just about the last thing an injured colleague needs is to inject biological goo into an already injured eye.

An alternative to weekly flushing plumbed eyewashes is to install non-plumbed systems in the facility. Inspection then becomes a matter of insuring the eyewash has not been activated and routinely replacing the fluid. An added bonus to these non-plumbed systems is they are always at room temperature when they are activated.

### ***Conclusions***

Preparedness is the key to any emergency. Preparedness is a combination of:

1. Anticipation of the emergency.
2. Training.
3. The right equipment at the right time.
4. Planning the emergency action, then following the plan. (Revising the plan when necessary).

Training chemical workers to handle emergencies cannot be overemphasized. Training builds confidence in one's abilities and reduces the tendency to panic when an emergency does occur. Training also lets supervision know where problems exist in controlled situations so they can be fixed before the real emergency occurs.

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