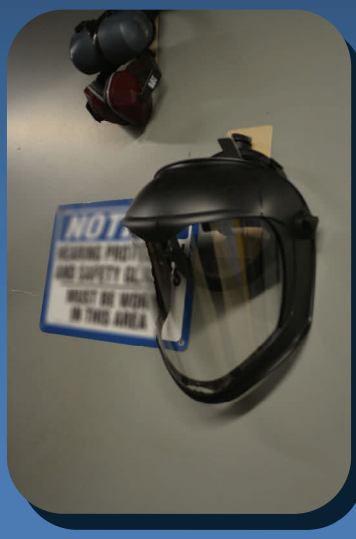
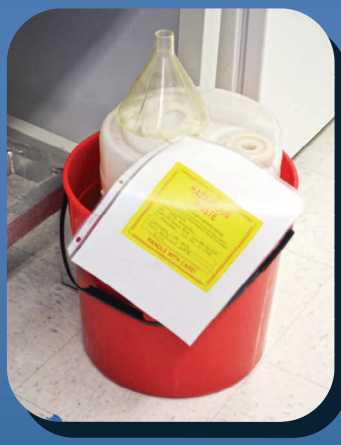
The Laboratory Safety Institute's

Laboratory Safety Guidelines

Expanded Edition









By James A. Kaufman, Ph.D

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Laboratory Safety Guidelines - Expanded Edition

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Introduction

"Laboratory Safety Guidelines" were written while I worked for the Dow Chemical Company in an attempt to share with schools, colleges, and universities what I was learning about lab safety. In 1976, Dow sent copies to 2,000 colleges and university chemistry departments and, with a year, received requests for 250,000 reprints!

In 1986, I assisted Dow with a revision of the guidelines. Dow sent this version to 10,000 high school chemistry teachers. Since then, over 2 million copies have been distributed and reprinted in various forms.

Most recently, LSI collaborated with both Carolina Biological Supply Company to produce a 2'x3' 4-color poster version and Fisher Science Education to create both a condensed safety tips version and an attractive, free wall poster. Over 15,000 copies have been distributed.

When LSI began publishing its newsletter, *Speaking of Safety*, I began expanding on and discussing each of the guidelines. This publication is the collection of expanded guidelines together in one volume.

The Revised, Expanded Guidelines

Revised 2014 – Short Version added

In the Spring of 2006, I decided to revise the Expanded Laboratory Safety Guidelines. LSI had just finished publishing all 40 suggestions for a Safer Lab in the Winter 2005-6 edition of Speaking of Safety. The cycle lasted almost seven years.

I've spent an awful lot of time thinking about lab safety in the past seven years. It's time to do a revision and see what comes out. There are going to be lots of new ideas, perspectives, and examples. There's going to be about 50% more content.

I hope you enjoy the result. As always, your comments and suggestion are welcome.

… Jim Kaufman

The Laboratory Safety Institute's…

Laboratory Safety Guidelines

40 Suggestions for a Safer Lab

Short Version

Steps Requiring Minimal Expense

1. Have a written health, safety and environmental affairs (HS&E) policy statement. Page 6

2. Organize a departmental HS&E committee of employees, management, faculty, staff and students that will meet regularly to discuss HS&E issues. Page 6

3. Develop an HS&E orientation for all new employees and students. Page 7

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7. Require all employees to read the appropriate safety manual. Require students to read the institution's laboratory safety rules. Have both groups sign a statement that they have done so, understand the contents, and agree to follow the procedures and practices. Keep these statements on file in the department office. Page 10

8. Conduct periodic, unannounced laboratory inspections to identify and correct hazardous conditions and unsafe practices. Involve students and employees in simulated OSHA inspections. Page 11

9. Make learning how to be safe an integral and important part of science education, your work, and your life. Page 13

10. Schedule regular departmental safety meetings for all students and employees to discuss the results of inspections and aspects of laboratory safety. Page 13

11. When conducting experiments with hazards or potential hazards, ask yourself these questions:
What are the hazards?
What are the worst possible things that could go wrong?
How will I deal with them?
What are the prudent practices, protective facilities and equipment necessary to minimize the risk of exposure to the hazards? Page 14

12. Require that all accidents (incidents) be reported, evaluated by the departmental safety committee, and discussed at departmental safety meetings. Page 15

13. Require every pre-lab/pre-experiment discussion to include consideration of the health and safety aspects. Page 16

14. Don't allow experiments to run unattended unless they are failsafe. Page 17

15. Forbid working alone in any laboratory and working without prior knowledge of a staff member. Page 17

16. Extend the safety program beyond the laboratory to the automobile and the home. Page 18

17. Allow only minimum amounts of flammable liquids in each laboratory. Page 19

18. Forbid smoking, eating and drinking in the laboratory. Page 19

19. Do not allow food to be stored in chemical refrigerators. Page 20

20. Develop plans and conduct drills for dealing with emergencies such as fire, explosion, poisoning, chemical spill or vapor release, electric shock, bleeding and personal contamination. Page 20

21. Require good housekeeping practices in all work areas. Page 21

22. Display the phone numbers of the fire department, police department, and local ambulance either on or immediately next to every phone. Page 22

23. Store acids and bases separately. Store fuels and oxidizers separately. Page 22

24. Maintain a chemical inventory to avoid purchasing unnecessary quantities of chemicals. Page 23

25. Use warning signs to designate particular hazards. Page 23

26. Develop specific work practices for individual experiments, such as those that should be conducted only in a ventilated hood or involve particularly hazardous. When possible most hazardous experiments should be done in a hood. Page 24

Steps Requiring Moderate Expense

27. Allocate a portion of the departmental budget to safety. Page 25

28. Require the use of appropriate eye protection at all times in laboratories and areas where chemicals are transported. Page 25

29. Provide adequate supplies of personal protective equipment - safety glasses, goggles, face shields, gloves, lab coats, and bench top shields. Page 27

30. Provide fire extinguishers, safety showers, eye wash fountains, first aid kits, fire blankets and fume hoods in each laboratory and test or check monthly. Page 28

31. Provide guards on all vacuum pumps and secure all compressed gas cylinders. Page 29

32. Provide an appropriate supply of first aid equipment and instruction on its proper use. Page 29

33. Provide fireproof cabinets for storage of flammable chemicals. Page 30

34. Maintain a centrally located departmental safety library (Page 30):

* "Safety in School Science Labs", Clair Wood, 1994, Kaufman & Associates, 101 Oak Street, Wellesley, MA 02482

* "The Laboratory Safety Pocket Guide", 1996, Genium Publisher, One Genium Plaza, Schnectady, NY

* "Safety in Academic Chemistry Laboratories", ACS, 1155 Sixteenth Street NW, Washington, DC 20036

* "Manual of Safety and Health Hazards in The School Science Laboratory", "Safety in the School Science Laboratory", "School Science Laboratories: A guide to Some Hazardous Substances" Council of State Science Supervisors (now available only from LSI.)

Continued on next page…

* "Handbook of Laboratory Safety", 4th Edition, CRC Press, 2000 Corporate Boulevard NW, Boca Raton, FL 33431

* "Fire Protection Guide on Hazardous Materials", National Fire Protection Association, Batterymarch Park, Quincy, MA 02269

* "Prudent Practices in the Laboratory: Handling and Disposal of Hazardous Chemicals", 2nd Edition, 1995

* "Biosafety in the Laboratory", National Academy Press, 2101 Constitution Avenue, NW, Washington, DC 20418

* "Learning By Accident", Volume 1, 1997, The Laboratory Safety Institute, Natick, MA 0176

All of these books are available from
The Laboratory Safety Institute
www.**L**ab**S**afety**I**nstitute.org

35. Remove all electrical connections from inside chemical refrigerators and require magnetic closures. Page 31

36. Require grounded plugs on all electrical equipment and install ground fault interrupters (GFI's) where appropriate. Page 32

37. Label all chemicals to show the name of the material, the nature and degree of hazard, the appropriate precautions, and the name of the person responsible for the container. Page 32

38. Develop a program for dating stored chemicals and for recertifying or discarding them after predetermined maximum periods of storage. Page 33

39. Develop a system for the legal, safe and ecologically acceptable disposal of chemical wastes. Page 33

40. Provide secure, adequately spaced, well ventilated storage of chemicals. Page 34

Laboratory Safety Guidelines Expanded

STEPS REQUIRING MINIMAL EXPENSE

#1. HAVE A WRITTEN SAFETY POLICY

This is the cornerstone of a good safety program. It's a statement endorsed and supported by the administration that speaks to the fundamental responsibilities for health and safety in the academic institution or company.

For example: "It is the responsibility of our (name of company or institution) and its employees to insure that our business activities (or educational programs and other activities) protect and promote the health and safety of our customers (students), our employees, and the environment."

Your department may want to draft a sample policy statement for recommendation to your administration or board of education. It is virtually impossible to have an excellent safety program without their support. Your written safety policy will provide the foundation of your safety program.

Policy statements of this type need to be signed by the highest ranking official of the organization, dated, laminated, and mounted in the entrance of every building.

When I was EH&S coordinator at Curry College, I got our president to sign a policy statement not unlike the one above. I made up seven framed copies. I took them with a hammer and nails to the offices of the president and his direct reports. I ask them where they wanted the colleges new EH&S policy statement (not if … where). I hung them prominently so both the senior administrator and his/her visitors could see it every day.

What is your company's or academic institution's safety policy statement? Please send us a copy to share with our readers. Would you like to receive a 16-page booklet containing a collection of 19 safety policy statements? Copies are available for $7.95 from LSI you can order them in our webstore www.labsafetystore.org

#2. ORGANIZE A SAFETY COMMITTEE

Your department should have a safety committee. Academic institutions and companies should all have safety committees. The committees should consist of employees, supervisors, faculty, staff, administration, and students.

The committees should meet regularly to discuss safety, health and environmental concerns/problems and to seek solutions to them. The committee should help to see that the safety policy is implemented. The committee can help to promote an interest and concern for health and safety issues. They might be the group responsible for conducting regular inspections, reviewing accident reports, and developing recommended safety procedures. Better is to be a coordinating group that engages all the other employees in the organization in these activities.

One type of safety committee is the central safety committee. It is chaired by the highest ranking onsite official. The members of the committee are his or her direct reports. In this way senior management/administration is involved and providing leadership in the safety program.

The central safety committee is the way they do it at DuPont. For more good ideas from DuPont, read *Excellence in Safety Leadership* by James Thomen. It's available from LSI.

How often does your committee meet? Once a year? Quarterly? Every other month? Monthly? More is more!

What responsibilities does your safety committee have? How well does the committee work? What problems do you have? Send us a list to share with other interested readers?

#3. DEVELOP A SAFETY ORIENTATION PROGRAM

All new employees, students, faculty, and staff should receive a specially designed indoctrination to your safety program.

This orientation should cover the philosophy, policies, and procedures. It should explain how to deal with emergencies and how to handle emergency equipment. The new person should receive a set of rules or operating manual for the academic institution or company and be expected to sign a statement (rules agreement) indicating that they have read, understand, agree to follow, and realize the failure to do so can result in termination.

When I started working for the Dow Chemical Company, my orientation took eight hours. I learned more about health and safety on that first day at Dow than I had in my prior 25 years in school.

I've asked over 50,000 scientists and science educators whether they received a New Employee Safety Orientation from their immediate supervisor on day one, only five percent say: "yes". I believe that pound for pound and dollar for dollar, the new employee safety orientation is one of the most important components in a safety program. And, you can't argue that it costs too much … no purchase order or requisition required.

Some schools require new students to have a three day orientation program and then score 100 on a test before they can begin attending classes. One college, in Minnesota, turned the first five labs in general chemistry into a 15 hour, one-credit, lab safety course. *Prudent Practices in the Laboratory* is used as the class text. There's a final. Students have three chances to pass the final. If they don't pass, they are done with science labs for that semester.

If you are involved in hiring new employees, consider asking the candidates the following question: "What is there in your background that suggests that you are both concerned and knowledgeable about issues of laboratory safety?"

You'll never have the special opportunity again that you have on day one to make a lasting impression about how much you care about health and safety.

Want to start your "new employee safety orientation" sooner? Add the two words, "Safety Conscious" to your display ad looking for new lab employees. Why not tell the whole world that your organization want "safety conscious" not "safety unconscious" employees.

Do you have a good safety orientation program? Tell us about it and we'll share your success.

#4. ENCOURAGE CARING ABOUT ONE'S HEALTH AND SAFETY

Employees, faculty, staff, and students need to be encouraged to develop a genuine concern about their own health and safety. It's too easy to care less and become careless.

One of the most important ways to do this is through education into the nature and seriousness of particular hazards and their potential consequences. I read of a hypothetical case where someone placed a rattlesnake in someone's mailbox. If asked if it were dangerous to reach into his mailbox, the owner would say, "of course not." Others who knew of the snakes presence might think differently.

A good way to make your point is through the use of examples where others have in fact been serious injured or killed doing exactly the same activity. This is why it's so very important for us to share our knowledge of these experiences.

LSI publishes a series of books titled "Learning By Accident" based on our collection of more than 5,000 accounts of laboratory accidents. Each volume in the series contains 500 anecdotal accounts. Volumes One, Two and Three are currently available for $19.95 each. The most serious accidents (over 300) have been compiled in a separate LSI publication, *85 Years of Progress*. See order form in back of booklet or order online at our web store.

Another good way to encourage others to care about their health and safety is to enforce the rules. It EH&S is going to be truly important in your organization, the rules need to be enforced. Otherwise, they are just lip service.

As a final example of a way to get others to care … lead by example. People pay a hundred times more attention to what you do than to what you say. Set the gold standard. Be the poster child for best safety practices.

As a teacher or supervisor, when you show a genuine concern for the health and safety of those that you supervise or teach, it encourages the development of their own concern. My first supervisor at Dow, Don Dix, was particularly effective in this respect and that contributed significantly to increasing my concern and interest in health and safety.

What do you do to show your concern? Let us know so we can share your success with other readers.

#5. INVOLVE EVERY STAFF MEMBER IN SOME ASPECT OF THE SAFETY PROGRAM AND GIVE EACH SPECIFIC RESPONSIBILITIES

You really need to find ways to get people involved. Students are people too, so don't forget them.

There's a tendency to think that if someone is appointed safety coordinator, they have to do all the work for the rest of us. False! A coordinator is just that. He or she is not a "parent". Each person needs to be responsible for safety in general and for a specific part of the program in particular. Here's a list of a number of different specific assignments:

Lecture bottle gas cylinders	Chemical inventory
Highly toxic compounds	Heavy metals
Emergency response	Pyrophorics
Reference materials	Oxidizers
Alcohol inventory	Acids and bases
Fire equipment	Refrigerators
Flammables storage	Showers and eye washes
Specimen storage	Electrical hazards
Accident records	In-service training

Get the idea? Everyone has a job to do. Everyone participates. Take turns doing a monthly lab inspection. Take turns presenting a 5-10 minute safety topic at department meetings. Take turns telling the principal/superintendent about needed repairs (with the department head's permission)!

Who is going to be responsible for the department's laboratory health and safety bulletin board? How about the "safety drawer" in each lab? Who makes sure that the drawer is properly stocked?

Want to review your emergency procedures? There are more than a dozen common types of lab emergencies. Why not have a different employee/student conduct the review at the monthly staff meeting?

Who does your chemical hygiene plan review? The CHO, the safety committee? Give it up! Give it to three, four, five members (students) of your department and treat them to the CHP review luncheon. Don't forget to give your boss or your boss' boss the leadership opportunity to send the reviewers a thank you note.

The best safety programs are the ones that get everyone most involved. Safety is not a spectator sport (sounds good - I'll have to remember that)! How do you get people involved? Let's hear about what you're doing?

#6. PROVIDE INCENTIVES TO STUDENTS AND STAFF FOR SAFETY PERFORMANCE

Everyone like to receive a reward for good performance. It can be a merit raise, it can be good grades, it can be a promotion, or it can be praise for a superior. Good performance deserves to be recognized and rewarded. Safety performance is no different. When it's done right, it should be recognized.

For students, grades and praise are good incentives. Bonus points for good performance. My lab grade report sheet that each student gets for each experiment has a section on safety performance.

For staff members it becomes more difficult. Academic Institutions do not usually give merit raises. Pay for endurance is more the rule! Even so, if you do staff evaluations, make safety one of the written criteria. Let staff members with good safety performance get recognized, appreciated, and generally treated in a way that others would want to behave similarly.

Make sure the folks who get promoted are good safety performers. Otherwise, you're giving a very mixed signal.

See if you can get the Dean, Department Head, or President to put on a special cookout for everyone if the school can set a special record of days without a disabling injury to anyone. Post the goal and keep visible track of your progress. "Our goal is an accident free Month - etc." How do you reward good safety performance? What works at your school or company?

Encourage faculty members to include "safety performance" in the section of their course syllabus that describes the grading criteria for the laboratory portion of the course.

#7. REQUIRE ALL STAFF MEMBERS TO READ THE APPROPRIATE SAFETY MANUAL.

- ✓ **REQUIRE STUDENTS TO READ THE INSTITUTION'S LABSAFETY RULES.**
- ✓ **HAVE BOTH GROUPS SIGN A RULES AGREEMENT.**
- ✓ **KEEP THESE STATEMENTS ON FILE IN THE DEPARTMENT OFFICE**.

This does several things. It makes you decide what the rules and policies are going to be. It shows everyone that you are concerned about health and safety. It keeps a permanent record of your safety standards.

This is important for staff. It makes the expectations very clear. Safety is part of good science and here's what we expect at our institution or company. Safety is part of doing any job right. It is particularly important for new employees. It sets the standard right from the beginning.

A good rules agreement consists of six part: (1) the rules, (2) the signed statement that your read, (3) understood, (4) agree to follow, realize the failure to follow the rules can result in termination, and (5) a cover letter signed by the organization's president or superintendent confirming that not following the rules can result in termination.

To get started, it is not necessary to write your own set of rules, policies, and procedures. Take some from the LSI Publications, Teacher's Resource Books, State Guides, NSTA or ACS publications. "Safety In Academic Chemistry Laboratories" would be a good starting point. Several States and school districts have good models to adopt or adapt. Check with your State Department of Education. The ACS Committee on Chemical Safety has just produced a safety guide for small businesses. Single copies of this or the original version are available for a nominal charge.

At the Dow Central Research New England Laboratory, I was given a 500-page safety manual on day one. I was asked to take it home and read it that night. When I returned in the morning I was expected to sign a statement in the front of the manual indicating that I had read, understood, and agreed to follow those procedures. I guessed they were serious about safety.

LSI has prepared the K-12 science safety manual for major USA school districts and has a model that is available for purchase.

Do you have a good safety manual? Please send a copy so others can learn from it. The lab safety manual "Laboratory Safety in Practice" published by Van Nostrand Reinhold is now available from LSI. LSI helped to produce and publishes an excellent Model Chemical Hygiene Plan. If your labs need a chemical hygiene plan or safety manual, email or call today to discuss LSI publications and development services.

#8. CONDUCT PERIODIC, UNANNOUNCED LABORATORY INSPECTIONS TO IDENTIFY AND CORRECT HAZARDOUS CONDITIONS AND UNSAFE PRACTICES.

- ✓ **INVOLVE STUDENTS AND EMPLOYEES IN SIMULATED OSHA INSPECTIONS**.

Inspections get people involved in thinking about hazards and unsafe practices in the workplace. These should be done at least four times a year (monthly is better). Perhaps, one of these can be done by people from outside your institution or company. This brings in fresh eyes to see the things you've grown accustomed to. Let everyone have a chance on some rotating basis to help conduct the inspection.

At Dow, we did it every month! It would be a good idea to consider having at least one inspection each year done by "outsiders". Ask the people from another department, another of your locations, another institution or a consultant to conduct an inspection. LSI discussed the merits of this approach in one of our newsletter, *Speaking of Safety*, editorials … “Safe Eye for the Lab Guy.”

Inspections are an integral part of a good safety program. This is your time to step back a little from your day to day involvement and look for problems and opportunities for improvement as well as things that are well done. Don't hesitate to praise good work, safe practice, improvements, and good ideas.

People need to feel that the inspections are being done to make the working and learning environment safer and healthier for all. They are not to blame or to get someone. At the same time, it may be necessary to note some unsafe practices.

Keep a written record of the inspection. Share the results with the department members. Let each person be responsible for making the necessary changes in their area except where outside assistance is needed. Use the inspection report as a check list to see that the situations are corrected in a reasonable period of time.

Regular inspections are one of the cornerstones of a good safety program. They are a great opportunity to take a good hard look at your working/learning environment to try to spot potential problems.

You need to be sure that the emergency equipment is in place, unobstructed, properly designated with signs, and properly functioning. Check electrical receptacles for correct wiring with a ground monitor. Check the hoods for proper air flow. Check the stockroom for security and overcrowding. See that benches and aisles are kept clear and free of materials that should have been put away. And so on….

As you conduct your inspection, make a written list of those opportunities that you identify for improving lab safety. When you're done, prioritize the list to identify the more serious issues. Give copies of the list to department members, the maintenance department, and the management and administrators. Now you need to work diligently at trying to make those improvements that are within your ability and resources. Seek assistance for the rest.

Having everyone participate in the inspection process is a great way to get them involved in the safety program and to teach them about hazards and how to recognize them.

Lastly, make lab inspections part of the college and university curriculum. Have the faculty member and his or her students do the inspection during a regular lab period. If more than one class uses the lab, the responsibility can be rotated among the various classes.

#9. MAKE LEARNING HOW TO BE SAFE AN INTEGRAL AND IMPORTANT PART OF EDUCATION, YOUR WORK, AND YOUR PLAY.

For too many years at academic institutions and some companies, health, safety and the environment has been something extra. It's time that it became part of the process. At Dow, we were told that we were being paid to do three things: (1) work safely, (2) conduct active research programs, and (3) publish the reports and patent disclosures resulting from our research. Safety was part of the job ... not something extra.

The slogan at the Bell System is: "No job is so important and no service so urgent that we cannot take time to perform our work safely". At Dow, it was each person's responsibility to be sure that their work could be performed safely. If you don't think it's safe to do, don't do it. LSI has paraphrased the Bell System slogan in one of ours: “No lesson is so important and no task so urgent that we cannot take time to teach, learn, and practice science safely.”

These kinds of attitudes and values are built over time by companies and institutions that make it very clear that they value safety. Educators (art, science, technology) need to have the time (as part of their regular working day) to set-up and test experiments, to look up the hazards of chemicals, to find out what protective equipment and protective facilities are needed. This is the job.

I hope art, science and technology educators will ask to be relieved from collateral duties to make time for these important safety, health and environmental responsibilities. English, math, history, and foreign language teachers don't have these needs. You do. And remember, if you never ask, you'll never get. If the principal says no, just think to yourself, "that's an interesting opening position!" Ask every chance you get until you get what you want!

There’s an interest quote from Jacob Riiss.

When nothing seems to help. I go and look at a stone cutter hammering away at his rock perhaps a hundred times without so much as a crack showing in it. Yet at the hundred and first blow it will split in two, and I know it was not that blow that did it – but all that had gone before.

#10. SCHEDULE REGULAR DEPARTMENTAL SAFETY MEETINGS FOR STUDENTS AND STAFF TO DISCUSS THE RESULTS OF INSPECTIONS AND ASPECTS OF LABORATORY SAFETY.

Safety meetings are an integral part of a good safety program. You need to have a time when you and your colleagues can get together and focus on safety issues. Meetings that come as a follow-up on a regular safety inspection provide a good basis for discussion of problems and needs.

Both undergraduates and graduate students can benefit from participating in these discussions. They become more familiar with safety problems. They see that the faculty is concerned about these issues. They may even contribute some good ideas. Remember, no one's been telling them for years that "it can't be done, it's never happened before, it won't happen here, and it's not in the budget."

Is a whole meeting too much for you to swallow! How about having safety as a regular agenda item on your normal department meeting. Set aside 10-15 minutes for a safety topic. Ask a member of the department to pick a safety topic related to his or her particular interests and present a five minute review for the benefit of the rest of the group.

Borrow one of the audio-visual programs from the Lab Safety Institute show it as part of your meeting. We have several that would be interesting and appropriate. LSI operates an audio-visual lending library with over 100 items. LSI member do not pay a rental fee, just the shipping and handling charges. Visit the LSI website (www.labsafetyinstitute.org) to see the list of library holdings.

#11. WHEN CONDUCTING EXPERIMENTS WITH HAZARDS OR POTENTIAL HAZARDS, ASK YOURSELF THESE QUESTIONS:

- ✓ **WHAT ARE THE HAZARDS?**
- ✓ **WHAT ARE THE WORST POSSIBLE THINGS THAT COULD GO WRONG?**
- ✓ **HOW WILL I DEAL WITH THEM?**
- ✓ **WHAT ARE THE PRUDENT PRACTICES, PROTECTIVE FACILITIES AND EQUIPMENT NECESSARY TO MINIMIZE THE RISK OF EXPOSURE TO THE HAZARDS?**

This is the world's simplest safety program. It represents the minimalist approach. If you want to know how little you can do and "get by", being able to answer these four questions is a good beginning point.

Can you identify the hazards that are present? Are they chemical, physical, biological, mechanical, electrical, radiation, noise, stress, or high/low pressure. Those are life's nine hazards and you should look for them before beginning an experiment.

What kinds of emergency situations can you anticipate? Fires, explosions, electrical shocks, bleeding, burns, cuts, poisonings, slips, trips and falls, spills, extreme weather, medical problems, workplace violence and natural disasters should be considered. What about other medical emergencies and utilities failures. And, everybody's favorite … a colleague who goes "postal." Are you prepared to deal with these kind of problems? Do you have written procedures describing what to do?

Do you have the necessary safety equipment and emergency equipment? Deluge showers, eye wash fountains, first aid kits, fire blankets, fire extinguishers, communication system?. What about gloves, goggles, and lab coats? What are the generally recognized safety practices that a reasonable person would follow before experimenting. Carefully reading labels and MSDSs is a good beginning. Hand washing when finished is another.

Have you considered reducing the scale of the experiment, substituting a less hazardous chemicals or eliminating the experiment altogether. Teachers/supervisors need to adjust the experiments so that the health and safety risks involved are appropriate for the facilities, the equipment, the experience of the teacher/supervisor, and the abilities of the students/employees.

Making those decisions is the teacher's/supervisor's responsibility.

Some organizations, both non-academic and academic, have a hazards review committee and/or process. The function is to try to make reasonably sure that all the issues have been properly considered. At Dow, we had to prepare a safe operating package and have it reviewed by two supervisors before starting certain hazardous experiments. One copy of the package was posted on the fume hood and one filed in the front office (in case the hood was on fire!).

An "Emergency Preparedness Review Checklist" is available. In addition to assisting in the planning for emergency responses, this LSI publication covers many safety program topics. The Review is available from LSI free for our members.

#12. REQUIRE THAT ALL ACCIDENTS (INCIDENTS) BE REPORTED, EVALUATED BY THE DEPARTMENTAL SAFETY COMMITTEE, AND DISCUSSED AT DEPARTMENTAL SAFETY MEETINGS.

While having no accidents isn't necessarily a good indication that everything's ok, having them go unreported makes the matter worse. The reporting of all accidents is extremely important. Every accident is an opportunity to improve your safety program, to learn how to do a better job, and to protect your workers and facilities.

Since accidents happen relatively infrequently, particularly in smaller organizations, keep track of the incidents and close calls/near-misses as well. These are the events where matters of inches or seconds were the difference between nothing happening, a minor mishap, and a major disaster. The rule of thumb is that there are three hundred minor incidents for each major one. Think of all you could learn from having a chance to review the close calls. When organizations provide an easy way for employees to self-report and share accounts of close calls and near-misses, the frequency of accident invariable goes down.

The safety committee should get copies of each accident or incident report and review it carefully. They should conduct an investigation of the event so that it can be correctly evaluated and the proper corrective action taken to prevent a reoccurrence. Don't go around looking for someone to blame. Looking to place blame is the quickest way to convince people that they shouldn't talk about what happened, to avoid telling the truth, or to have a loss of memory.

Then, the event should be brought to the attention of the rest of the people in your organization at a departmental safety meeting or by other means so that they too can learn from the experience. Photographs of injuries and property damage are graphic reminders of the consequences of carelessness, unsafe work conditions, and unsafe work practices.

At Cornell University, a review of the lab accidents for the prior several years revealed a pattern. There was one particular undergraduate lab experiment that was responsible for a disproportionate number of accidents. Changing the experiment helped to reduce the accident frequency.

Consider having an accident/incident report form for your employees and students to fill out. In the case of students, it will help them to develop an appreciation for this recordkeeping aspect of safety.

#13. REQUIRE EVERY PRELAB DISCUSSION TO INCLUDE CONSIDERATION OF HEALTH AND SAFETY ASPECTS.

When the guidelines were first written in 1976, this was not a common practice. Fortunately, we've made some progress in this area. Many science faculty now realize that this is essential and must take place.

Providing instruction in the safety hazards, appropriate precautions and potential emergency procedures is one of a teacher's duties under the law. Failure to do so can result in being found negligent by reason of nonfeasance, i.e., failure to provide a warning.

The use of a "Hazard Review Form" is a good way to formalize this procedure. Prepare a list of all the hazards present, the necessary precautions, and the appropriate emergency responses. This will allow the teacher to end up with a written record of the instructions that have been given for each class on each day.

How do students/employees know that a particular topic of instruction is important? You give emphasis, you set a good example, and you test on the material. Be sure to have quiz and test questions on your safety instruction. I really like the Ebbing lab manual because each set of pre-lab questions contains the question "What are the precautions required in this experiment?" (See #14 … the big four)

Take it one step further. Add … “What are the hazards? What would be the worst things that could happen? What are the prudent practices, protective facilities and protective equipment need to minimize the risk?”

An "Emergency Preparedness Review" is available. In addition to assisting in the planning for emergency responses, the 16-page brochure covers many safety program topics. The Review is available from LSI free for our members.

#14. DON'T ALLOW EXPERIMENTS TO RUN UNATTENDED UNLESS THEY ARE FAILSAFE.

There are surely going to be times when experiments must continue running on their own while you do other things (go out to lunch or home to sleep). At these times, it's important to consider all the things that could go wrong in your absence and to prepare for them.

For example, what would happen if there were a power or compressed air failure and the stirrer were to shut down? What if the water gets turned off or a cooling hose detaches? Get the idea? Cooling hoses need to be clamped or wired on.

What about the water shut down? Do you need a special sensor for water, temperature, pressure, fluid level, etc. to control the experiment in your absence?

The name, address, and phone number of the person responsible for an experiment should be prominently displayed. In addition, clear directions should be provided on how to safely shut down the experiment in your absence. Special hazards and precautions should be noted. Your experiment shouldn't become someone else's land mine.

One of Dow’s policies was the unattended experiments should be set up in such a way the they “fail safe.” They automatically shut down if a failure occurs rather and create a runaway situation (overheating or over pressurizing).

#15. FORBID WORKING ALONE IN ANY LABORATORY AND WORKING WITHOUT PRIOR KNOWLEDGE OF A STAFF MEMBER.

Working alone is a bad idea. It's an open invitation to tragedy. The legal consequences can be equally serious.

For students at the secondary level and undergraduates in teaching laboratories, this means constant adult supervision. It means that only previously approved experiments are performed.

For graduate students, post doctoral fellows, and science faculty, it means that there is always a second person, available to provide immediate assistance in the event of an emergency. This second person should be knowledgeable about the work being performed and capable of rendering assistance if necessary.

Experimental procedures should be reviewed by science faculty prior to their use. This practice helps to insure that significant hazards are identified before the experiments are performed. It was a standard operating procedure in the Dow Chemical New England Research Laboratory and makes very good sense for all research programs.

The legal consequences of allowing students to work alone or without proper adult supervision are significant. Since all the professional associations (NSTA, ACS, NSC, NAS, NRC, etc....) clearly state that this is an unacceptable practice, you would be hard pressed to win a law suit if a serious injury occurred. A smart plaintiff's attorney would point to these professional standards and show the defendant's conduct to be wanting.

Forcing a person to assume an unnecessary risk can resulting a claim of malfeasance if the there is an injury caused by the act or inaction.

The National Safety Council's (1121 Spring Lake Drive, Itasca, IL 60143-3201) Research and Development Section has published (June '87) a safety and health information sheet on "Off-Hours Laboratory Work".

In the real world, it would be presumptuous to expect that all working alone is going to end. I'm a big fan of the Jiminy Cricket School of Optimism (when you wish upon a star … etc.). However, in the meantime, what can we do to minimize the risk? How about a $50 pair of walkie talkies to provide a sound link between two people in different locations? How about a $30 per month service that provides a button you can press to get help in an emergency? You know … "Help. I've fallen down and can't get up."

#16. EXTEND THE SAFETY PROGRAM BEYOND THE LABORATORY TO THE AUTOMOBILE AND THE HOME.

The effectiveness of safety programs depends on their ability to motivate people to care about their health and safety. When people view this caring process as part of their whole life and not just part of their job, it becomes all the more effective. In fact, the same hazards exist outside of work and school as do within.

Help your students/employees to understand the importance of safety throughout all of their lives. Most of the nearly 100,000 accidental deaths and 20,000,000 disabling injuries that occur each year in the United States do not happen in the workplace. The injury is just as severe and the loss of resources and productivity is nevertheless just as great.

Many small, inexpensive safety reminders are available that can help to deliver this message. For example, the EPA has a "Read The Label" campaign. There are four brochures on protecting your pet, your garden, your kids, and your household. They are available on request or can be downloaded from their website, http://www.epa.gov/opptintr/labeling/campaign.htm.

LSI publications "Sources of Handouts" and "Laboratory and Occupational Safety Bibliography" list many free and inexpensive materials you could use to enrich your safety program. Each is available in our Laboratory Health and Safety Notebook, which you can purchase in our webstore. www.labsafetystore.org

#17. ALLOW ONLY MINIMUM AMOUNTS OF FLAMMABLE LIQUIDS IN EACH LABORATORY.

There seems to be a special law of nature that leads to the accumulation of chemicals in laboratories. When these chemicals are flammable, the safety of the lab's residents can be seriously compromised. Maintaining only those minimum amounts needed for the day's work is the best way to address this common problem.

The National Fire Protection Association (Batterymarch Park, Quincy, MA 02169) has developed guidelines for the amounts of flammable liquids that should be kept in laboratories. These guidelines are contained in their valuable publication #45, "Fire Protection for Laboratories Using Chemicals."

Besides establishing limits for the total volume of flammables per 100 square feet of lab space, code 45 recommends maximum container sizes and material of construction (glass, metal, etc.) for various classes of flammable liquids. Less is better.

There have be a regrettably large number of school science demonstration accidents where student are severely burned. In almost all of them, the quantity of flammable liquid that was out on the demo bench vastly exceeded what was needed to perform the demonstration. In one case the teacher needed about 0.5 milliliters and has the one gallon container on the bench.

#18. FORBID SMOKING, EATING AND DRINKING IN THE LABORATORY.

The practice of forbidding smoking, eating, and drinking in laboratories is one of the basic good hygiene practices. Unfortunately, it is often one of the most frequently disregarded. Too many people seem to have a "good reason" for continuing these bad habits. None of these reasons are good enough.

These practices protect people in laboratories from ingesting toxic chemicals or infectious materials. The stuff that's on your hands ends up in your mouth.

I've watched science department heads drink coffee while supervising the lab. I've seen teachers make stir-fried vegetables in a wok in the lab between classes for lunch. Don't do it. Set a good example yourself and enforce the rules.

Set up a separate area that can be used for taking breaks, making coffee, and consuming food. Don't allow it in the lab. And that includes applying cosmetics, too.

It’s not only a bad practice but it is also against the law. Two OSHA regulations speak specifically to this unfortunately widespread practice. One is the bloodborne pathogens standard, 29CFR1910.1030. The other is the sanitation standard, 29CFR1910.141(g)2/4.

There are many worthwhile experiments that involve eating something. For example, teaching colligative properties by making ice cream. Take your students to the cafeteria, use paper plates and plastic utensils and teach your students about safe practices at the same time. Remember, safety is a teachable moment.

Also remember, Pierce College in Tacoma, Washington was sued for 2.5 million dollars following the death of a young woman. She drank a saline solution as part of an A&P class. It contained sodium azide as a preservative. She died four days later.

Many laboratory have ice machines. They should be clearly labeled: “This Ice Is Not for Human Consumption”.

A 35-page "Laboratory and Occupational Safety Bibliography" of health and safety references is available in our Laboratory Health and Safety Notebook. Order through our webstore.

#19. DO NOT ALLOW FOOD TO BE STORED IN CHEMICAL REFRIGERATORS.

Prohibiting the storage of food in chemical refrigerators is another one of the basic rules of good practice. Like those above, it is intended to prevent the ingestion of toxic or infectious materials. The food will absorb the vapors from the chemicals in the refrigerator and then they'll be consumed.

Post a clear warning sign on any chemical refrigerator: "Chemicals Only; Do Not Store Your Food Here"

Assign one person the responsibility for each refrigerator. They can check it periodically to be sure there's no food and no unlabeled containers. They can also see that the inventory list is up to date, the refrigerator is functioning properly and does not need to be defrosted.

A related problem is caused by carrying a pack of cigarettes in your pocket while working in laboratories. The tobacco adsorbs chemicals from the air (like a dosimeter). Then when you go outside to "clean air", the adsorbed chemicals are burned and inhaled. Illnesses have been traced to the inhalation of these chemical combustion products.

The storage of food and beverages where they may exposed to hazardous substances is specifically prohibited in the OSHA sanitation standard, 29CFR1910.141(g)2/4.

#20. DEVELOP PLANS AND CONDUCT DRILLS FOR DEALING WITH EMERGENCIES SUCH AS FIRE, EXPLOSION, POISONING, CHEMICAL SPILL OR VAPOR RELEASE, AND PERSONAL CONTAMINATION.

The list is incomplete. Let's add bleeding, burns, medical situations, electric shock, and weather emergencies.

One of my biggest surprises was discovering about 20 years ago that teachers do not have written emergency plans and that they don't discuss these issues in their science departments. When questioned about these two points, only about 5% of science teachers say yes. What about your company? Most are not much better! I've ask about 50,000 scientists and science educators. Yikes!

The only good way to prepare for an emergency situation is to think through how you should respond and then practice doing it correctly. Regular drills and exercises are essential. In most cases, the first decision involves deciding whether to evacuate or not. No one will ever fault you for saving your students and losing the facilities.

If you are starting from scratch in your department, have an emergency of the month. Assign one of the above emergencies to a pair of teachers/employees and ask them to draft a model response to be discussed at the next department meeting. The following month, pick a new emergency and a new teacher/employee pair. In small departments/companies, invite the arts, physical education, industrial arts, and office and maintenance people to join with you.

One last word of advice ... PRACTICE. You can't get good at anything without practice. Dealing with emergencies is no exception. Each month, ask the folks in one of your labs to decide what would be the worst thing that could happen in their lab. Let them stage a mock event and have everyone else respond (hopefully) appropriately. Afterwards, sit down together and ask two simple questions (Brian Tracey's Platinum Questions)

1) How did we do?
2) How can we do it better?

#21. REQUIRE GOOD HOUSEKEEPING PRACTICES IN ALL AREAS

Good housekeeping is one of the foundations of good safety practice. When people are trained to clean-up and put things away as soon as they are done using them, their work areas are safer, more spacious, and more productive.

From the condition of some chemistry laboratories, you would think that this critical lesson had never existed let alone been heard. It's so basic that it's part of the world's simplest safety policy: Work safely, Clean-up, and get results.

Some people think they can save time and get more done by allowing things to pile up and get cleaned-up later. They are sadly mistaken and laying the foundation for a serious accident or injury.

Science educators need to take a long hard look at the priorities they are teaching their students. When you allow your students to keep working right up to the bell, what are they learning about the importance of good housekeeping. You know, it doesn't have to cost you a penny to decide that parts E, F, and G of the next experiment are less important than giving your students time to clean-up and then requiring it.

I used to have a weekly winner of the Nelson Eddy and Jeanette McDonald look-alike contest. (My students had no idea what I was talking about). Two students had to stay till the end and be

responsible for cleaning-up whatever they had not reminded and insisted that their classmates clean-up.

#22. DISPLAY THE PHONE NUMBERS OF THE FIRE DEPARTMENT, POLICE DEPARTMENT, AND LOCAL AMBULANCE IMMEDIATELY NEXT TO EVERY PHONE.

In an emergency, you tend to forget even the most common things. Having emergency phone numbers and directions by every phone is a very important reminder. Substitute teachers and others new to your facilities need this reminder even more. Don't obstruct this vital information with other posted notices around the phone.

If your phone is an intercom, it's still important to have emergency information by so that anyone can use it effectively in the event of an emergency.

Providing extra phone number stickers to your employees, faculty, staff, and students is another good way to extend that safety program beyond the workplace/classroom.
Test the emergency communication system periodically (at least once a year). When would be the worst time to discover that it doesn't work at described. During LSI's facilities inspections, we routinely do this. Occasionally, we find one that isn't working.

What should you do if you have no phone? Better be planning ahead as discussed above. One relatively inexpensive solution might be a pair of wireless walkie talkies or intercoms (Radio Shack/Best Buy $50-100). Another good practice is to train a pair of students as emergency responders. They know where to go and who to speak to in an emergency. Special red emergency hall passes help to insure that they get immediate assistance and that their message is taken seriously.

#23. STORE ACIDS AND BASES SEPARATELY. STORE FUELS AND OXIDIZERS SEPARATELY.

The proper storage of chemicals has become a focal point of laboratory safety. We need to keep chemicals which are incompatible separated some reasonable distance from each other. At the same time, the law of diminishing returns applies here. One can expend a significant amount of energy and not receive much additional protection for the effort.

Today, most chemical manufacturers have settled on a five color scheme for segregating chemicals. Red for flammables, blue for health hazards, yellow for oxidizers, white for corrosives, and a fifth color for less hazardous materials. Fisher uses gray for the fifth color, Baker/Mallinckrodt uses orange, Science Kit uses green and so on.

Within these categories some additional separation is recommended. Acids and bases need some separation. They would react violently if the two broke and mixed. Within the acids group, put the oxidizing acids (perchloric and nitric) off by themselves.

Keep all your flammables (solvents, fuels, etc.) separate from your oxidizers (nitrates, perchlorates, azides, peroxides, etc.). Within each of the categories, chemicals can be arranged alphabetically.

A free poster showing how to safely store chemicals is available from LSI. Requests should include a stamped ($1.59), self-addressed 10"x13" envelope labeled “Media Mail”. Ask for the ChemAlert Safe Storage Chart. It lists the common lab chemicals which are found in each color category and provides a place for emergency phone numbers..

Having said all this about segregation of chemicals, I would only add one final observation. Arrangement is last on LSI’s list of what's important for chemical storage. Number one is security - keeping the door locked or access controlled. Number two is having adequate space. Number three is ventilation. LSI recommends one cubic foot of air per minute per square foot of floor space (with a minimum of 150CFM. Number four is fire protection. The worst way to discover a fire in the chemical storeroom is by opening the door (It happened in New Hampshire). Have an alarm system. Number five is shelving security. How do you know that the shelving won’t tip over, fall off the wall, or collapse? You had better inspect it regularly.

Arrangement is last on LSI’s list.

#24. MAINTAIN A CHEMICAL INVENTORY TO AVOID PURCHASING UNNECESSARY QUANTITIES OF CHEMICALS.

One school accumulated 20 five-pound bottles of mercury. Each year they ordered from the same list that they had used the year before! Not a good idea. You need to know what you have, where it's located and who’s responsible for it.

Whether you decide to do it with sheets of paper, index cards, or computers, you need to have a chemical inventory. It's pretty hard to comply with OSHA, EPA, and state right-to-know regulations without one. It's pretty hard to know what to order without one. And in New York, starting July 1991 it became the law for public elementary and secondary schools. Unfortunately, the law was the result of the serious injury to two middle school children in Peekskill and a $50,000,000 law suit.

If you decide to use a computer to keep your records, you can use any word processor, spreadsheet or database software program you like. Or, you can buy a program from one of the several vendors which offer the software packages. Programs are available that run on either IBM or Macintosh type systems.

Look at the feature and see what meets your needs. How easily can additional chemicals be added to the database? Can the total list be sorted or indexed? How fast does it search? Can extra fields of information be added? How many?

You can order a chemical storage software through LSI on our webstore www.labsafetystore.org

#25. USE WARNING SIGNS TO DESIGNATE PARTICULAR HAZARDS

The use of warning signs to designate particular hazards is not just a good idea. It's the law. The OSHA Laboratory Standard 29CFR1910.1450 requires that those areas in which particularly hazardous substances (select carcinogens, reproductive toxins, and highly toxic substances) are used be clearly designated. The OSHA Hazard Communication Standard requires the labeling of hazardous chemicals in the workplace.

Hazard labeling should not be limited to chemical hazards. Mechanical, Biological, Physical, Noise, Radiation, Hi/Low Pressure, Electrical, and Stress hazards should all be clearly indicated with appropriate signs.

Good signs should go beyond hazards and extend to the facilities and equipment we use to deal with these hazards: emergency equipment and emergency facilities. OSHA regulations require the emergency equipment be identified with prominent signs.

Take a good careful look at your labels and see if they can't be improved. Can you make it easier to recognize the hazard and the means of dealing with it? Are cabinets for corrosive storage clearly labeled? Are the circuit breakers in all your electric panels clearly labeled? Do preserved specimens have the identity of the preservative and appropriate hazard warnings on the labels?

The August 1991 issue of "Safety and Health News" from the National Safety Council had a good article on labeling. It contained the names and addresses of the many companies selling labeling products.

Chemical labeling is one of the topics covered in our training seminars and short courses. For more information contact THE LABORATORY SAFETY INSTITUTE (192 Worcester Road, Natick, MA 01760-2252 508-647-1900; FAX: 508-647-0062; Email: info@labsafetyinstitute.org; Website: www.labsafetyinstitute.org).

#26. DEVELOP SPECIFIC WORK PRACTICES FOR INDIVIDUAL EXPERIMENTS, SUCH AS THOSE THAT SHOULD BE CONDUCTED ONLY IN A VENTILATED HOOD OR INVOLVE ESPECIALLY HAZARDOUS CHEMICALS

This simple idea preceded by 15 years the requirements of the OSHA Lab Standard for "Standard Operating Procedures", "Control Measures" and "Special Provisions for Working with Particularly Hazardous Substances". Today "it's not just a good idea, it's the law!"

While the Lab Standard does not require specific work practices for individual experiments, it does stipulate that employers generate a list of recognized good practice which lab workers are expected to follow, i.e., wash hands before leaving the lab, never work alone, leave lab clothing in the lab, don't eat, drink or smoke in the lab, etc..

Control measures include elimination, substitution, engineering, administrative, and personal protective equipment (PPE) as methods for managing risks. Employers are responsible for insuring that their lab employees understand these controls and can easily determine when to implement them. For example: when should chemical splash goggles be worn? Chemical splash goggles should be worn (1) whenever a chemical/biological known to be hazardous to the eye is being handled, (2) whenever a chemical/biological with unknown eye hazard is being handled and (3) any liquid hotter than 60 degrees Celsius.

Particularly hazardous substances include "select carcinogens, reproductive toxins, and highly toxic substances". The Lab Standard says that the employer must decide (1) whether these must be used in a "designated area", (2) when to work in a fume hood or other enclosure, (3) if

procedures need to be developed for "decontamination", and (4) how to achieve the "safe removal of contaminated waste".

LSI believes that the scope of particularly hazardous substances should be expanded. There are others in the lab that may need some additional precautions. We would like to see highly flammable (class IA solvents), highly corrosive (concentrated and fuming acids), and highly reactive substances (picric acid, explosives).

Thanks to Rose Colby (Goffstown, NH), LSI developed a simple "Hazards Review Form". It serves several purposes. First, it provides a framework or structure for considering the hazards, precautions, and emergency procedures for each experiment. Second, it can be a vehicle for encouraging new employees to think first about hazards, precautions and emergency procedures. And, third, it provides a record of safety instruction when used as a checklist during pre-lab briefing. It helps to ensure that all points are covered and documents that this important instruction has occurred.

Copies of the "Hazards Review Form" are included in our seminar notebooks. Individual copies are available from for our members in the members only section of our webstore.

STEPS REQUIRING MODERATE EXPENSE

#27. ALLOCATE A PORTION OF THE DEPARTMENTAL BUDGET TO SAFETY.

The establishment of a separate accounting line for environmental, health and safety related purchases is essential. This allows you to clearly track monies expended for this purpose. It also reduces the likelihood that budget reductions in other areas will occur.

In the budget planning process, staff members should be asked to contribute suggestions for expenditures needed to maintain safer, healthier, and environmentally friendlier operations and to continue to improve the EHS program.

When it is possible, managers and department heads should bear in their budgets the costs of accidents, injuries, and illnesses which occur to the people they supervise. This provides a greater accountability for health and safety. The direct allocation of HS&E costs to department budgets stimulates interest in the reduction of these expenses.

Each department needs to establish a line item in its budget for safety. Requests for safety materials, equipment, references, facilities, etc. should not be part of other budget line items.

In doing this, two things will happen. Safety grows in importance by being recognized as a separately funded aspect of the work. And, the funding of safety matters is less likely to be at the expense of other budget lines, i.e., the cost of safety goggles no longer has to come out of general supplies and expenses.

Some universities have the unfortunate practice of requiring research supervisors to purchase safety equipment out of their research grant funds. This is fine if a professor has funding and

has properly budgeted for the safety equipment. For less well-funded faculty members, the department in general needs to provide the necessary safety equipment.

This same funding practice needs to be followed by institutions as well as individual departments. Once an institution has established a health and safety policy (see guideline #1), it needs to establish an institutional line item to fund its Health, Safety and Environmental Affairs Program.

How does your institution budget for safety? Let us know so we can share your approach with others. One suggestion that I would offer is that whenever the budget making process goes on, the question should be asked: "What are the safety and emergency supplies, equipment, and facilities that are needed to do this work in a safe, healthy, and environmentally sound way?"

#28. REQUIRE THE USE OF APPROPRIATE EYE PROTECTION AT ALL TIMES IN ALL LABORATORIES AND AREAS WHERE CHEMICALS/BIOLOGICALS ARE TRANSPORTED.

Appropriate eye protection is defined by the American National Standards Institute (ANSI) Z-87.1 standard. The most current edition is 2003 (OSHA references the 1989 edition. The standard describes both the design and performance criteria for various devices and the type of device to be used for particular operations (five different types of hazards).
OSHA requires (29 CFR 1910.133) that the employer provide these devices and that the employee use them. The devices must meet the ANSI Z-87.1-1989 standard. Hopefully OSHA will acknowledge the existence of the newer editions of this ANSI standard (2003).

Polycarbonate lenses provide better protection but were not included by ANSI until the 1989 standard was issued.

Most chemical companies require that workers in laboratories wear industrial standard safety glasses (plain or prescription) with side shields as minimum protection. Some require side shields that are either permanently attached. A few do not permit frames of conducting material (metal).

As the nature and degree of the hazard increases, the amount of protection used should also increase. Chemical splash safety goggles should be worn when (1) handling chemicals or biologicals known to be hazardous to the eyes, (2) using chemicals or biologicals which you don't know if they are hazardous to the eyes, and (3) working with liquids which are hotter than 60 ^{o}C. Note that safety goggles of the "impact type" (directly ventilated) are not suitable for chemical splash protection. Impact safety goggles are intended to provide greater protection from solid particles than safety glasses.

Sometimes making the distinction between safety glasses and safety goggles can be difficult. Remember, the safety goggle seals to the face or fits the face snuggly. If you can stick your finger between the device and your face, it is not a safety goggle. It might even be safety glasses with a strap (headband temple as ANSI calls it).

If the chemical, biological or operation may injure the face, mouth or neck, a face shield should be worn. According to the ANSI standard, face shields are to be used in addition to chemical splash goggles.

The use of contact lenses in the laboratory is encouraged by the ACS Committee on Chemical Safety, Prevent Blindness America, and most other eye care organizations. In 2005, NIOSH published a "Current Intelligence Bulletin" which speaks in favor or the use of contact lenses in the lab environment.

#29. PROVIDE ADEQUATE SUPPLIES OF PERSONAL PROTECTIVE EQUIPMENT - SAFETY GLASSES, GOGGLES, FACE SHIELDS, GLOVES, LAB COATS, AND BENCH TOP SHIELDS.

Employers are responsible for identifying workplace hazards and deciding which personal protective equipment (PPE) is needed for proper protection. Employers are also responsible for ensuring that devices are available. If employees provide their own safety equipment, the employer is responsible for ensuring that it is appropriate. Respirators must be provided by the employer.

The OSHA Personal Protection Standard requires employers to do workplace hazard assessment to determine the protective equipment needed. The employer must then provide the equipment and train employees in its use. In addition, the employer needs to maintain records that both the hazard assessment and the training have taken place.

As part of both 29CFR1910.132 compliance and its chemical hygiene plan, the employer needs to specify the circumstances under which an employee should use PPE. When should safety glass with side-shields versus chemical splash goggles be worn? When should gloves be used? What about lab coats and portable shields? Is hearing protection an issue? Should hearing protection devices be used?

The employer has an additional responsibility. The employer needs to make sure that the PPE is used. It's not a matter of employee choice. Employees who fail to use required PPE should receive appropriate warnings, disciplinary action, and then be dismissed. Working safely should be a condition of employment.

Any policy that falls short of providing for the provision of dismissal is inviting violations that cannot be addressed and prevented. It allows employees to jeopardize their own health and safety and that of others around them without the possibility of necessary disciplinary action. Normally, it will not be necessary to invoke this final action. However, the availability of the sanction improves the compliance efforts.

#30. PROVIDE FIRE EXTINGUISHERS, SAFETY SHOWERS, EYE WASH FOUNTAINS, FIRST AID KITS, FIRE BLANKETS AND FUME HOODS IN EACH LABORATORY AND ACTIVATE OR CHECK WEEKLY.

Fire extinguishers need to be appropriate to the type of fire. Type A fires form an **A**sh. A water extinguisher is for fires involving burning wood or paper. Type B fires consist of **B**oiling liquids like oil and grease. Carbon dioxide is an extinguisher for B type fires. Type C fires carry an electric **C**harge. Halon substitute extinguishers and dry chemical powders are to be used here. Active metal fires are type **D**. Sand, sodium chloride and copper metal powder can be used on these fires. A restaurant kitchen deep fat fryer fire is type **K**. Potassium Acetate is used in these extinguishers

The extinguishers should be mounted at the correct height and designated with a sign above to indicate the location.

The American National Standards Institute (ANSI) Z-358.1-2004 standard provides design and performance recommendations for safety showers and eye wash fountains. It recommends weekly activation and annual testing.

Safety showers should provide water at a rate of 20 gallons per minute for at least 15 minutes. The valve should be a single-action level which stays on until it is pushed off.

Eye wash fountains should have a similar type actuating lever. The flow rate should be 0.4 gallons per minute for eye wash only and 3.0 gallons per minute for eye wash/face wash combination devices.

First aid kits need to be specified by the consulting physician. Employees should be trained in the appropriate use of the materials provided. First aid and CPR courses can be offered.

Fire blankets are very useful. They can be used as a temporary stretcher, to cover up after disrobing in the safety shower, to extinguish a fire on equipment or a person (while he or she is doing the "Stop, Drop and Roll", to prevent shock, and as a pillow for comfort to an injured person.

Fume hoods are your most important protection against toxic volatile chemicals. Airflow of 80 to 120 lfpm is recommended.

The OSHA Lab Standard require that employers indicate in the written chemical hygiene plan how these devices will be maintained and who is going to be responsible to checking and testing them. Monthly inspections are appropriate.

The inspection process is an opportunity to involve employees, managers, and students. Make them all part of the inspection procedure on a rotating basis.

For information about our *Eyewash Fountain Checklist*, Vaneometers, or *Model Chemical Hygiene Plan*, contact:

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192 Worcester Road, Natick, MA 01760-2252 TEL: 508-647-1900; FAX: 508-647-0062; Email: info@labsafetyinstitute.org; Webstore: www.labsafetystore.org.

#31. PROVIDE GUARDS ON ALL VACUUM PUMPS AND SECURE ALL COMPRESSED GAS CYLINDERS.

This is one of the most common OSHA violations. Whenever a pulley/belt assembly is within reach, there needs to be an enclosure to prevent fingers, hair, or clothing from being caught.

Paper cutters are another common device that requires a guard.

In both cases, manufacturers can provide the parts to upgrade older units that are missing the necessary protective guards.

Compressed gas cylinders need to be chained in place during storage, transportation, and use. If the valve were to break off, the cylinder will become a rocket causing potentially significant injury and/or property damage. In addition, a falling cylinder can cause crippling injuries.

In the storage area, compressed gas cylinders should be separated according to hazard category: flammables, oxidizers, inerts, and empties. When transported, a wheel cart with a restraining chain should be used. In both cases, the protective cap should be kept on.

There are five different types of valves on compressed gas cylinders. If you don't know and understand the types of valves, you will not be able to open or close the cylinder properly.

Compressed gases is one of the topics covered in our training seminars and short courses. To register for a course or see our course schedule please visit our website. www.labsafetyinstitute.org

#32 PROVIDE AN APPROPRIATE SUPPLY OF FIRST AID EQUIPMENT AND INSTRUCTION ON ITS PROPER USE.

There are some emergencies which can't wait five minutes for EMT's to arrive. Severe bleeding is one of these. A person can bleed to death in three to five minutes depending on the severity. Employees need to be available to deal effectively with this and other serious emergencies.

OSHA specifies in 29 CFR 1910 that first aid kits need to be specified by the consulting physician. Employees should be trained in the appropriate use of the materials provided. First aid and CPR courses can be offered. You can't expect people to respond properly to emergencies unless they have an opportunity to practice.

Proper first aid in the case of a spill of chemicals on a person is to use the safety shower in less than ten seconds and to remove all contaminated clothing immediately. This is no time for modesty (although shower curtains or fire blanket screens are appreciated).

You never get good at anything unless you practice. Make up a card that says: "You have just splashed concentrated nitric or sulfuric on yourself." Drop the card on one of your employees or students two or three times a year to start the safety shower/fire blanket drill. If you generate

one or two less data points that day, it's ok. You've just said to everyone (by your actions) that working safely in the lab is more important than making widgets!

Speaking of first aid, what's the first thing you do if your clothing is on fire? That's right … stop … drop … and roll.

What's the second thing? Ah ha! Not as easy. The correct answer is lots of cold water in the shower to take the head away to stop the "cooking" process.

#33. PROVIDE FIREPROOF CABINETS FOR STORAGE OF FLAMMABLE CHEMICALS.

Flammable liquids should be stored in fireproof cabinets. The NFPA provides recommendations in codes 45 and 30 for the quantities of materials that should be stored in labs in and out of these cabinets.

There is no federal requirement for these cabinets to be vented.

Assign a staff member to be responsible for oversight of the cabinet. This responsibility can include checking to make sure that containers are properly labeled, caps are tight, and the inventory on the cabinet door is up to date.

A checklist for the storage of flammable liquids is available from LSI.

#34. MAINTAIN A CENTRALLY LOCATED DEPARTMENTAL SAFETY LIBRARY.

One of the characteristics of an effective safety program is the availability of reference and resource materials. Employees need to have easy access to this information. Your chemical hygiene plan, your material safety data sheets, and other references should not be far away. Don't make it hard for people to get answers to safety questions.

- "Safety in School Science Labs", Clair Wood, 1994, Kaufman & Associates, 101 Oak Street, Wellesley, MA 02482
- "The Laboratory Safety Pocket Guide", 1996, Genium Publisher, 1 Genium Plaza, Schnectady, NY
- "Safety in Academic Chemistry Laboratories", 1998, ACS, 1155 16th St., N.W.,
- Wash, DC 20036
- "Manual of Safety and Health Hazards in The School Science Laboratory", 1984.
- "Safety in the School Science Laboratory", 1979, NIOSH
- "School Science Laboratories: A guide to Some Hazardous Substances" Council of State Science Supervisors (now available only from LSI.) 1984

- "Handbook of Laboratory Safety", 5th Edition, CRC Press, 2000, Corporate Blvd, N.W., Boca Raton, FL 33431
- "Fire Protection Guide on Hazardous Materials", 1997, National Fire Protection Association, Batterymarch Park, Quincy, MA 02269
- "Prudent Practices in the Laboratory: Handling and Disposal of Hazardous Chemicals", 2nd Edition, 1995
- "Biosafety in the Laboratory", 1989, National Academy Press, 2101 Constitution Avenue, N.W., Washington, DC 20418
- "Learning By Accident", volume 1 (1997), volume 2 (2000), and volume 3 (2003); The Laboratory Safety Institute, Natick, MA 01760
- Laboratory Waste Management: A Guidebook, ACS RCRA Task Force
- Biological Safety: Principles and Practices, Diane Fleming, ASM
- Handbook of Chemical Health and Safety, Bob Alaimo, Oxford Press
- Working Safely with Chemical, Hugh B. Kareful, Genium

All of these books are available from LSI. A 39-page "Laboratory and Occupational Safety Bibliography" is also available.

#35. REMOVE ALL ELECTRICAL CONNECTIONS FROM INSIDE CHEMICAL REFRIGERATORS AND REQUIRE MAGNETIC CLOSURES.

Standard refrigerators should not be used for storage of flammable or reactive chemicals. Electrical connections within the refrigerator can be an ignition source for flammable vapors. In fact, it's been reported that there are nearly a dozen sources of ignition in a standard household refrigerator.

The motor under the refrigerator is also a potential ignition source. Explosion-proof refrigerators have their motor and compressor assemblies encased in an enclosure to prevent ignition. In addition, the refrigerator is wired with explosion-proof connections to the receptacle.

If the door has a latch mechanism instead of a magnetic closure, pressure built up in an explosion will blow the door off and cause more serious damage.

Every year two or three refrigerators explode because of improper storage. Make sure your refrigerators are correct for your application.

#36. REQUIRE GROUNDED PLUGS ON ALL ELECTRICAL EQUIPMENT AND INSTALL GROUND FAULT INTERRUPTERS (GFI'S) WHERE APPROPRIATE.

The National Safety Council reports that about 1000 people are electrocuted each year in the United States. In 2005, a biology professor at Cleveland State University died as the result of an electrical shock in the lab.

OSHA specifies that most equipment in the workplace be grounded to avoid shock and possible electrocution. Removing or breaking off the ground pin is a bad and potentially fatal idea.

Most people are not aware of the danger associated with ungrounded equipment. This danger is compounded when the plug is a two-prong unpolarized type. If inserted backwards, the case of the appliance can be electrically hot. We find many in labs that are 50 to 120 volts hot.

This same problem can be cause by two other circumstances: (1) the electrician wires the receptacle backwards or (2) the appliance manufacturer does not follow the convention. In any of these three cases, if you near a ground, serious or fatal shocks can occur. Make sure that the ripple side of the appliance cord is connected to the wider side of the receptacle.

A ground monitor or circuit analyzer can be used to ensure that the receptacle is correctly wired. An AC-Sensor can tell you if the case of the appliance or device is electrically hot or not. A Tension Tester will indicate if the receptacle is holding on to the plug's prongs with sufficient force to meet electrical code specifications. All three tests should be performed annually on receptacles and electrical equipment in the lab.

The use of Ground Fault Interrupters (GFI's) can provide significant shock protection. They should be installed in any location where the receptacle is within six feet of a ground or water is likely to be present on the floor or surfaces.

Circuit Analyzers and AC-Sensors are available from THE LABORATORY SAFETY INSTITUTE. Call or email for more information.

#37. LABEL ALL CHEMICALS TO SHOW THE NAME OF THE MATERIAL, THE NATURE AND DEGREE OF HAZARD, THE APPROPRIATE PRECAUTIONS, AND THE NAME OF THE PERSON RESPONSIBLE FOR THE CONTAINER.

Don't leave a booby trap for another person. Make sure that all containers are appropriately labeled. OSHA's hazard communication standard and lab standards require labeling of containers.

As the containers get smaller, this requires some practice and creativity to provide sufficient information. Color coding, signal words, and flag label can be helpful.

Develop the habit of preparing the label and then filling the container.

Remove chemical label from empty containers before relabeling or discarding to avoid confusion about the contents.

When a new chemical is received, mark the date received, the full level, the initials of the individual who will be the “steward” for that container, and the date opened. The steward needs to be the one who wanted to order the chemical and is now most knowledgeable about the safe use, storage and disposal of the chemical.

#38. DEVELOP A PROGRAM FOR DATING STORED CHEMICALS AND FOR RECERTIFYING OR DISCARDING THEM AFTER PREDETERMINED MAXIMUM PERIODS OF STORAGE.

Some chemicals have a short life expectancy. Others will remain good for a long time. Solvents which form peroxides are one example substances requiring periodic testing. Ethers, vinyl compounds, alcohols, ketones, and aldehydes are some of the peroxide formers. Your chemical inventory system should provide reminder dates.

Bottles should be marked when they are received and when they are opened. In addition, draw a line on the bottle with a china marking pencil or other marker to indicate the full level. This mark will serve as a useful guide to indicate how rapidly the material is being used up and to gauge the remaining amount.

Peroxide formers need a special label to indicate the required interval for peroxide formers, the date the test is performed, and the initials of the individual performing the test and certifying that the test was successful (negative).

#39. DEVELOP A SYSTEM FOR THE LEGAL, SAFE AND ECOLOGICALLY ACCEPTABLE DISPOSAL OF CHEMICAL WASTES.

We recommend the establishment of a chemical management system. This system provides for the safe procurement, storage, use and disposal of chemicals.

The system begins with the assumption of responsibility. Management needs to have written policies for the safe use and disposal of chemical and biological materials. A hazardous waste coordinator needs to be appointed to oversee the process and be thoroughly familiar with the state and federal regulations. The facility needs to function as a single site. Safe disposal of hazardous wastes needs to be everyone's responsibility.

Today, more than 40% of the chemical disposed of from laboratories are perfectly good unopened containers. A good chemical inventory is essential to avoiding the purchase of unneeded materials. Next, it's more effective to buy small quantities and discard empty containers. When the cost of disposal is factored in, the larger size may no longer be the most cost-effective.

Adopt strategies for waste minimization. Exchange unwanted surplus materials, recycle and reclaim by-products, substitute less hazardous materials and use smaller scale reactions when

possible. Acid and base streams can be neutralized. Hazardous wastes can be processed in the collection vessel.

The Laboratory Safety Institute's (LSI) seminars **Developing A Chemical Management System** and **Laboratory Waste Management** provide real world strategies for cost-effective reduction and disposal of hazardous wastes. LSI has published “The Golden Rules of Chemical Waste Disposal”. Members can download this free in our webstore www.labsafetystore.org

#40. PROVIDE SECURE, ADEQUATELY SPACED, WELL VENTILATED STORAGE OF CHEMICALS.

In academic institutions, the most serious issue is the restriction of access to hazardous chemicals to appropriate personnel. Students and others will steal chemicals. Keep the door to the storeroom locked and only allow authorized people to get at these materials. Today, we are even more concerned about the misuse of lab chemicals. Keep the door locked.

The space provided for chemical storage should be sufficient to permit containers to be no more than two deep on a shelf. There should be enough room between containers to permit a hand to reach in and remove a bottle without knocking something off the shelf.

Put a supply of colored, adhesive dots in the storeroom. Have everyone mark the cap of everything used for the next year. At the end of the year, make up a list of the unmarked containers. Send the list to waste disposers for a bid in removal.

Chemical store room ventilation is recommended to be one cubic foot per minute per square foot of floor space. The minimum recommended level is 150 cubic feet per minute.

The use of lips on shelves is recommended in locations where earthquakes, hurricanes, or tornadoes are likely. In this case, a removable wire insert type is suggested.

About the Laboratory Safety Institute

The Laboratory Safety Institute is a nonprofit organization whose mission is to make health and safety an integral and important part of science education, work, and life. LSI provides training, consultations, publications, audio-visual materials, and responds to requests for information.

LSI was founded in 1978 as The Laboratory Safety Workshop by James A. Kaufman, Ph.D.. His experience working for the Dow Chemical Company convinced him that schools and colleges were not doing enough to encourage health and safety. Studies by LSI and others have shown the accident rate at schools and colleges to be 100 to 1000 times that of Dow and DuPont.

Since 1978, Dr. Kaufman has trained over 100,000 science educators and scientists. His brand of safety training is a unique blend of technical information, practical and inexpensive solutions, humor, and accounts of accidents drawn from a collection of over 4,000 examples.

LSI has produced two lab safety, training audio-visuals*: The One-Day Lab Safety Audio Course* (5.5 hours) and *The Two-Day Lab Safety Video Short Course* on DVD

LSI publishes a newsletter: *Speaking of Safety*.

LSI offers lectures, seminars, short courses, webinars, audits and inspections, and regulatory compliance and safety program development consultations throughout the world for academic, industrial, medical, and government laboratories.

LSI operates an Internet discussion list, LABSAFETY-L, and maintains an informative website (http://www.labsafetyinstitute.org)

LSI is supported by corporate sponsors, agencies, associations, generous individuals, its members. Members receive a newsletter subscription, use of the audio-visual lending library without rental fee, a 10% discount on most publications, a 5% discount on training, and use of the Toll Free, 24-hour Lab Safety Information Hotline.

The Journal of Chemical Education called The Laboratory Safety Institute "A national resource for safety conscious science teachers". If you would like to help support the efforts of The Laboratory Safety Institute: (1) Subscribe to "Speaking of Safety", (2) Become a member of LSI (partially tax deductible), and (3) Make a contribution (tax deductible).

Free copies of our “Laboratory Safety Guidelines”, Publications List, Audio-Visual Lending Library List, and Introduction to The Laboratory Safety Institute (containing seminar schedule and membership information) are available on request. For more information about LSI, contact:

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About the Author

Dr. James Kaufman is President of the Laboratory Safety Institute, President of Kaufman & Associates and former Professor of Chemistry at Curry College. He received his bachelor degree in chemistry from Tufts University and his doctorate in organic chemistry from Worcester Polytechnic Institute.

After two years as a post-doctoral fellow in the WPI Chemical Engineering Department converting garbage into fuel oil, Dr. Kaufman joined the Dow Chemical Company's New England Research Laboratory as a Process Research Chemist. During his four years with Dow, he became increasingly involved in laboratory safety related activities. He authored "Laboratory Safety Guidelines". Originally distributed by Dow, now over two million copies of the widely requested and reprinted brochure are in circulation.

Dr. Kaufman is the founder and president of The Laboratory Safety Institute - a national, non-profit center for safety in science and science education. LSI's lectures and training programs, AV lending library, and publications help academic institutions throughout the world. LSI is supported by grants from individuals, foundations, companies and professional societies.

As a safety consultant, his company, Kaufman & Associates, conducts seminars, short courses, audits and inspections for schools, colleges, and companies. They also provide advice on regulatory compliance, safety program development, facilities design and editorial commentary on laboratory texts.

Dr. Kaufman is a former, ten-year member of the American Chemical Society's (ACS) Council Committee on Chemical Safety and is past-chairman of the 2,500 member ACS Division of Chemical Health and Safety. He is the author-narrator of the ACS Audio Course on Laboratory Safety and editor of "Waste Disposal at Academic Institutions" from Lewis Publishers. He recorded and edited the "One-Day Laboratory Safety Audio Seminar" and "Two-Day Lab Safety Video Course." He co-edited the LSI publication: “Safety Is Elementary, the new standard for safety in the elementary science classroom.”

Most recently, Dr. Kaufman was appointed chair of the Safety In Science Education Committee of the International Council of Associations for Science Education (ICASE).

www.LabSafetyInstitute.org

World Safety Conference

WorldSafety is a conference that is ideal for anyone with an interest in laboratory and chemical safety. This is a chance to hear from leading speakers from around the world, to network with other safety professionals and contribute to an education discussion on how we can improve safety and ensure all take on a safety first culture. Each year this conference is held in a different country.

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