Some Thoughts on Teaching Chemical Health and Safety

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History

In 1976 I started a course called "Occupational Safety and Health," which emphasized chemical hazards, but included coverage of the OSHAct, pressure-vacuum systems, physical hazards--electrical, radiational, etc. The clientele was largely junior and senior science majors. The most striking feature of student feedback on the course was *anger* -- that no one had told them of all these hazards until they were ready to graduate! Although today's incoming students have much more awareness of chemical hazards in some respects, the need for more sound information and education remains as strong as ever.

As originally constructed, the course included an industrial hygiene lab that required an on-the-job health evaluation project. More recently the lab has been made optional.

Problems

With respect to reaching all chemistry students, or even all chemistry majors, a separate course may not be the way to go. For one thing, no such course, however well prepared, delivered, and received by students, can possibly replace the day-to-day safety *awareness* imparted by a concerned instructor, who is working elbow-to-elbow with the students. For another, the presence of such a course might be used as an excuse by some for not providing the ongoing safety and health advice that is needed.

The biggest problem can be resistance from colleagues. We know of a case where a "colleague" one day got his hands on the lecture notes for a chemical safety and health course taught by another department member, and had a work-study student throw them in the dumpster of the Science Center! Years later he explained to an interim dean that the reason was that this course was "not real chemistry." While this is [we hope!] an extreme example, the problem of lip service to safety and health, or considering it not worthy of real chemists, is not uncommon. It has been a continual struggle to keep our course in safety and health required for chemistry majors, to the extent that it is now required only for the B.S. candidates. Notwithstanding the primacy of the subject, arguments that students simply do not have time or "room" for an entire course in chemical safety and health in their freshman year do have some validity. There *is* too much to know, and perhaps we are teaching too much stuff, as I have heard some argue in other venues. Further, it is difficult to resist, e.g., administrative directives that no major program should require more than 40 credits in the major.

The option offered in lieu of a required safety and health course was "You make a safety video, and we'll show it in the first lab of every course." Need we say that that approach is also a way NOT to engender a safe working attitude among students of chemistry? Videos can be very helpful, and we have used them, but the trap of thinking that safety is done in the first lab of the semesterand then can be forgottenis too common.

The maintaining of a log of accidents--*and near-misses*is frequently considered to be good practice toward an improved safety situation in a department. As you probably know, accident and illness logs are in fact required by the US Occupational Safety and Health Administration[OSHA]. That is true for those institutions which come under OSHA, or whose state regulations require it, but do be very careful: if everyone else in your department or school does not sign on to the practice, the paper trail over several years could make it look as though *your* students were the only ones having accidents! A clear and strong, written departmental policy, with sanctions for non-compliance by faculty or staff, can help. If you are the only one complying with such a policy or regulation, it might be time to state that in writing, with copies to all and sundry.

Chairs or administrators who will spend money on anything but improving safety and health; colleagues who persist in running risky labs, insist on keeping peroxide-forming compounds in the stockroom without continual testing; who order 5-gallon cans of reactive compounds that are rarely or never used, or who boast Ill go until somebody stops me! are a menace to all of us! Academic freedom is a precious and wonderful thing, but too many individuals in universities, colleges, and some high schools get away with near-murder when it comes to chemical safety and health. Such individuals *must* be controlled for the safety and health of both students and staff! If you succeed in doing so, please write me immediately and tell me how you did it!

Seriously, the academic model often does not seem to lend itself well to correcting bad safety and health situations. Even when a campus does hire a safety officer, or perhaps has an entire department for the purpose, if the safety personnel do not have sufficient authority, things may not get much better risk-wise. Indeed, the safety people are often caught in the middle, recognizing dangerous situations, but without the authority to change them. Smaller institutions usually cannot afford to hire such personnel, so it may be up to you literally to effect the desired change. More about correcting bad situations later.

"Efficiency expert" students have been another ongoing problem: Beware the student who says to his/her lab partner "You look up the safety and health information for this compound while I prepare the standards!" Such a person may be the very one who needs to read an MSDS thoughtfully [--and maybe the partner is the very one who needs some more practice making up solutions]. Again, its up to YOU to catch and correct such situations.

What worked

In retrospect, these three decisions have had the greatest impact toward improved safe and healthful working attitudes on the part of my students:

1. *Have a zero tolerance for unsafe attitudes or practices:* If you are serious about safety, *you* must show it! Put a requirement for working safely in your syllabus, and make that an explicit part of the grade. For example, spell out that anyone caught not wearing his/her safety goggles may get [not more than] one warning, and will suffer grade reduction the first time, and ejection from the course for subsequent offenses. When *you* get really serious about safety and health risks, the students will too, but *you* set the tone

2. *Require that the safety and health hazards of each chemical be determined and written down BEFORE any one opens a bottle.* In my experience, this one practice has probably resulted in the greatest improvement in genuine student respect for the substances used in the laboratory. Having looked up the Material Safety Data Sheet [MSDS] and/or other reference information, students do seem to realize that bad things *can* happen, and that the onus of achieving a low-risk lab experience rests not simply on the instructor, but on them too. *Test* on this information too!

This implies that some kind of chemical health and safety library is available close to or in the lab. That could be as simple as a computer wired to the Internet. Some hard copy references can be very helpful too. We have acquired a bookcase of such material over the years, and students do use it. Please see the Resources section of this paper for some suggestions. Both hard copy and Net access is probably the best combination.

3. *A safety and health analysis and hazard summary for the entire experiment is required as a part of each lab report.* This section should address, for example, hazards of sampling, use of electrical equipment, etc., and not be simply a prcis of the MSDS. For what it may be worth, I ask for a summary in their own words,

both to encourage some thought and writing on their part, and to discourage their printing the MSDSs and attaching them to the report without having read them.

I would add a few more practices that seem to have been helpful:

4. *Introduce the students formally to how to find chemical information, and then test them on it.* How this is done will of course depend on your situation, but in my opinion, it is one of the most long-lasting skills we can try to impart to our students. In my case, I set up an early-in-the-semester session in the library, with an emphasis on electronic literature searching. A reference librarian can be a great help here, and can, for instance, show students working at their own terminals how the construction of their query, or the database that they are in, can make the difference between success and failure in their finding the desired health or safety information. A tour of the library is included.
That session is followed up by a couple of assignments to find specific information [e.g. an MSDS, then a certain paper] and email said documents to me. It is easy to construct a form letter that is emailed to each member of the class, requesting him/her to send you a certain MSDS. The fun starts when you change part of one line in the middle of the form letter and assign a different compound to each student. You will quickly find out who the leeches are! Be ready with your grading policy to address the many excuses you will hear or read as to why they sent you the MSDS for their roommates compound! The percentage of those doing their own work will usually rise dramatically on the next assignment.

5. *Consider having the students sign safety contracts.* While this practice has been judged to be everything from highly advisable to useless, we have continued it because it seems to help to convince students that they do have some responsibility for their own safety and health, and that this is serious business. By no means does it absolve you, me, or our institutions from our obligations, of course.

6. *Consider providing each lab student with a copy of the booklet Safety in Academic Chemistry Laboratories*[*]*.* This involves a very modest investment, and in our opinion has also helped to raise student awareness and knowledge level in this area. I put a copy in each student locker, with the locker number permanently and prominently written on the cover. Students are encouraged to take these home for careful study in preparation for lab work [and possible exam questions]. The booklets are returned or purchased at semesters end. At $3.50 each, these are a superb bargain, and provide the student with a hard copy of some important basics. We should not expect our students to remember everything that we said in a long safety instruction session at the beginning of a course, and this publication provides an excellent primer in another medium. An important side benefit is that good practice on the part of the prof and the department is included in the booklet, which provides an extra impetus to keep us on our toes!

Lab Instruction

Instruction in this area is of course necessary--each lab period. Rather than lecturing to them, one technique that has worked well is rather to **ask them** "What *could* happen?" This gets them thinking about possibilities. The lab instructor can then steer the suggestions and/or provide hints to ensure that all foreseeable hazards have been addressed, and good practices shown.

A longer general session at the beginning of the semester, before any lab work starts, can be helpful toward having each student internalize the possibilities, as opposed to taking notes blindly. That can be followed by weekly *ad hoc* instruction.

The challenge of reaching into the heads of students suffering from what someone has called "YMIS," "Young Male Invincibility Syndrome," is not trivial, yet one must be careful to bring each student to genuine respect for each chemical, without causing fear in other personality types.

Project or research work, and environmental sampling bring their own special hazards, from working with a much larger unknown factor, to hyper- or hypo-thermia, thin ice, etc., all of which must be addressed *before* the students proceed to do the work. We strongly recommend at least the buddy system for fieldwork. Extra instruction and foresight on the part of the instructor is *definitely* in order.

Do you proctor your own labs? If so, are you *really* in there with your people--*all* the time? The difference in safe working attitudes and knowledge between students with absentee instructors and hands-on, work-with-them instructors is enormous!

If a TA teaches your labs, has that person really received full and proper instruction? Does s/he really believe that safety comes *first?* Do you check *frequently* to see how things are going?

You college and university types: while running your labs from your office, with frequent checks into the lab, may seem to be efficient, we suggest that both you and your students are missing something **very** important when that is the practice.

Have you considered awarding grade points for good suggestions to make the lab safer or healthier?

Formal Instruction

There is so much that any science major should know before going into the workplace or grad school, that a full course in the subject may well be justified. In our experience, industry is much more safety conscious than most school labs, which is embarrassing, at the least. We should be turning out graduates who can hit the ground running, not only with respect to running a gas chromatograph, but also with respect to what OSHA does or does not require of employers and their representatives. Similarly, our graduates should have a sound grasp of what can and cannot legally be put down the drain, or vented to the outside. How *does* one know if a hood is working properly?

How much instruction did you get in vacuum system safety--and health? Peroxide formers? Water-reactives? Radiationionizing and non-ionizing? Sound/noise hazards and their control? **Electrical** safety? The *psychology* of safety? How to communicate with management so that safety and health issues are addressed and corrected? There simply is not enough time in the crowded lecture and lab periods we have to do justice to most of these important topics, yet they *are* important, and probably more so than knowing every organic reaction or P Chem. calculation.

The time is long past when five minutes at the beginning of lab is enough safety instruction, and should be long past when at least chemistry and biology majors receive one semester of formal instruction in this critical area of their professional lives. So if you have the will, we would say, Go for it! i.e. put in that course in the subject of chemical health and safety, or health and safety in the lab or other workplace! Youll learn a lot doing it, and so will your students who live through the experience with you each time you do it.

There are instances where a hybrid between an entire course and the ongoing in-lab instruction may be appropriate. Two examples among my courses where this seems advisable are in the course called Environmental Chemical Analysis, and another called Chemistry and the Environment.

In Environmental Chemical Analysis, studentstypically Environmental Studies or other non-chemistry science majors--did not seem to realize sufficiently the nasty properties of typical pollutant analytes, so an approximately two-week section of the course is now devoted to flammability, reactivity, and toxicity hazards of chemicalsin the lab, in the shop, and/or on Superfund sites.

In Chemistry and the Environment, a course populated largely by Environmental Studies non-science majors, a similar section has been introduced, since these people frequently have need of such knowledge once out in the workforce, but may not realize that while they are students. Also, they may well need such knowledge to help them in their roles as environmentally concerned citizens.

In any full course, or sub-section as just described, a word of caution may be in order with respect to teaching the reactivity section, viz. we now have a heavy duty to walk that tightrope between providing adequate information for people to work safely, or supervise others to do so, but without aiding any would-be terrorist. It could also be prudent to review any class handouts from this same point of view.

Put it in Writing!

Finally, we would suggest that, if you see any condition or scenario that needs correction or improvement safety- or health-wise, or need any item[s] of equipment, software, etc. to teach this subject well, **report it, or ask for it--and in writing!** The decision of whether there be sufficient funding for a needed item, and all decisions about allocation of resources, are not ours, but belong to administrators. We faculty do have an obligation to know the hazards, to know and teach safe and healthful work practices, but if we only ask verbally, and/or do not persist in seeking adequate attention to these matters, then heaven forbid should something bad happen, we could find ourselves alone on the witness stand. We may have complained to colleagues about something for many years, but if we were not serious enough about correcting the situation to lodge a formal, written request, where is the proof that we were seriously concerned?

What administrator would dare refuse you when you ask formally and in writing for something you need to make things safer or healthier for the students? For that matter, students, like children, learn well by example, and can "absorb" from our actions just how serious we are about improving safety and health. Knowledge without action will not make the lab a safer and healthier place. The combination of the two can. I can virtually promise you that you wont believe how successful you will be in such requests once you **put it in writing!**

Resources

In the lecture section of the course, I like to start, rather than finish, with a section that I call Resources. In that form, I use an eight-page handout that lists names, addresses, urls, and other contact information for various agencies, organizations, etc. that might have information a person working in chemical health or safety might need. I encourage them to go to the source to get their information, in order to avoid inadequate or mis-information or misinterpretation, with their attendant problems. Going through that list with the students serves as an overview of the various branches of the subject, as well as a convenient way of introducing lots of vocabulary and general tips. More than one Safety major has appeared hat in hand six months or a year later, asking for another copy of that handout to replace the one he had misplaced! It is quite impossible for us to tell them all they need to know, but we must help them learn how and where to find out what they need to know.

In this on-line forum, on-line resources are the order of the day, so here are a few suggestions for you, the chemistry teacher:

1. The ***NIOSH Pocket Guide to Chemical Hazards***: covering only about 600 substances, this publication [NIOSH Publication No. 99-115] I have long recommended as the best $10 or $20 one could spend. NIOSH is the National Institute for Occupational Safety and Health, chartered by the OSHAct as the education and research agency in this area. Happily, the publication is now available on the web: http://www.cdc.gov/niosh/npg/npg.html

It is also available as a CD [DHHS (NIOSH) Publication No. 2001-145, August 2001] from www.cdc.gov/niosh, or at 800-35-NIOSH.

2. The bible with respect to toxicological information is of course ***RTECS****, the* ***Registry of Toxic Effects of Chemical Substances****.* Although a publication of NIOSH, ironically one of the better places to obtain this is the Canadian Centre for Occupational Safety and Health, at www.ccohs.org. This critical reference is available as a CD that is updated quarterly, or on-line for more money. You may be able to convince your library or school to make the purchase if you or your department cant afford it.

By all means check out their website for tons of fabulous links to help you in your teaching!

3. The ultimate reference for reactivity hazards is also not cheap, but probably is **Brethericks Handbook of Reactive Chemical Hazards**. It is available as a hardcover edition [$295], as well as on CD or on-line. Try http://www.bh.com/bretherick/ for further information.
4. ***Safety in Academic Chemistry Laboratories***: Now in its sixth edition, the excellent little book from ACS should be available via http://membership.acs.org/c/ccs/publications.htm or at 800.227.5558. Email address is oss@acs.org. Single copies are free to teachers, or $3.50 for multiple orders. Check out the many other gems here, e.g. ***Chemical Safety for Teachers and Their Supervisors, Grades 7-12***, ***Safety Audit/Inspection Manual***, ***Less is Better***, etc.
5. Before I forget, by all means lets include dear old **ACS itself**, and especially the **Division of Chemical Health and SafetyCHAS**and its publication ***Chemical Health and Safety***. As one example, the January, 2001 issue [**8,** No. 1, pp6-7] featured the CHAS editors choice Chemical Safety Professionals Reference Library, by Harry Elston, Jay Young, and the board of editors of *CHAS.* If you are an ACS member, Divisional membership is the way to get the most from your membership: http://membership.acs.org/c/chas/ The **Division of Chemical Education** http://divched.chem.wisc.edu/index.html and the **Journal of Chemical Education** http://jchemed.chem.wisc.edu/ are probably your **prime sources** for this kind of information and education, as you already know. Remember too that you can search the *Journal*s indexes and even read full articles on line with no extra charges!

   Chemical and Engineering News[C&EN] http://pubs.acs.org/cen/index.html has a long tradition of prompt communication on safety and health problems via its Letters section, and that collection of letters is now on line at http://pubs.acs.org/cen/safety/index.html .

   ACS also has a new video course ***Starting with Safety***, available from http://www.vcampus.com/acs. [In 2002, a 30-day subscription is $50; 1 year is $500.]
6. For Material Safety Data Sheets, my favorite is http://siri.org, which tries very hard to maintain current MSDSs, and encourages us users to get same directly from the manufacturers, who are supposed to update them regularly. This site is used most heavily by my students! **SIRI is Vermont Safety Information Resources, Inc**. The site also has a discussion board, email list archives, and lots of useful links.
7. The American Conference of Governmental Industrial Hygienists, at http://acgih.org/ is another prime resource for updated information on the health hazards of chemicals. Besides the flagship **Threshold Limit Values, or TLVs**, they publish many other useful references, including a classic manual on ventilation.
8. Dont forget **OSHA** itself, the Occupational Safety and Health Administration [under the US. Dept. of Labor] at www.osha.gov for lots of useful information, and its sister agency **NIOSH** http://www.cdc.gov/niosh , listed above.
9. Another prime source can be ***The Science Teacher*** *http://www.nsta.org/169* Its June 1999 issue [**1999,** ***66***] was devoted to safety issues, according to Steve Long in *J. Chem. Educ.,* **2000,** ***77,*** 21. NSTA itself has lots of resources at your disposal too, but you have to seek them out.
10. The Howard Hughes Medical Institute www.hhmi.org/research/labsafe/overview.html has published dozens of Lab Chemical Safety Summaries, available on the web, and has a number of free videos that might be useful to teachers. The videos are aimed at workers in biomedical and molecular biology areas, but do provide some basic instruction in areas like chemical hazards, radionuclide hazards, chemical storage, etc.
11. The **U.S. Environmental Protection Agency** at www.epa.gov has loads of material that could be of use to you in your teaching. As one example, the Chemical Emergency Preparedness and Prevention OfficeCEPPOhas http://www.epa.gov/ceppo/ lots of stuff that might be useful. Another is their educational page, at http://www.epa.gov/epahome/educational.htm. Although a bit tangential to chemical safety and health, EPAs page of terms and acronyms http://www.epa.gov/OCEPAterms/ is one that is very handy when dealing with Governmentese alphabet soup, and another place to which I send students with their individual assignments, in hopes that they will tarry awhile in the vast reaches

of the EPA website.

12. Remember too that EPA administers SARA and its Title III, EPCRAthe Emergency Planning and Community Right to Know Act. The Toxics Release Inventory, or TRI http://www.epa.gov/tri/ under that legislation is another rich source for getting students involved by looking up local real or potential sources of chemical releases to the environment. Students can then be assigned to find the health and safety properties of some of the substances found.
13. The **Agency for Toxic Substances and Disease Control**, or **ATSDR**, at http://www.atsdr.cdc.gov/ is another federal government agency whose site can be a rich source of useful material for you and your students.
14. The **National Fire Protection Association, NFPA,** at www.nfpa.org is another golden resource. Its *Fire Protection Guide to Hazardous Materials* *http://www.nfpa.org/catalog/product.asp?pid=HAZ01* contains NFPA 491, the *Manual of Hazardous Chemical Reactions.* Although it seems that 491 can no longer be purchased separately, even the $115 for the Fire Protection Guide is money well spent by your library, since in the *Manual* you can look up any chemical in which you are interested, and find abstracts and *literature references* to any reports of this substances having been involved in a violent or vigorous reaction. This is the ultimate and most convenient reference about **what NOT to mix with what!** NFPA also publishes the Standard on Fire Protection in Laboratories Using Chemicals [NFPA 45], the National Electrical Code, etc.
15. **Many other national organizations** can help you! As you can see by now, the problem is perhaps not so much that you dont know enough about chemical hazards, as that there is too much information! Nonetheless, specific organizations can give you authoritative information within their bailiwicks, and be most valuable resources to you. Do you want to learn the facts about radiation limits? The National Council on Radiation Protection and Measurements [NCRP] at www.ncrp.com is the definitive place to go. Do you have a question about compressed gases? Contact the Compressed Gas Association [CGA] at http://www.cganet.com/. The American Industrial Hygiene Association [AIHA] at www.aiha.org is the professional association for practitioners of that multi-discipline, offering everything from a 5MB publications catalog to lab accreditation, a list of occupational health, safety and environmental consultants, and more.

    You get the idea
16. **Regional organizations:** Groups like the **New England Association of Chemistry TeachersNEACT** at www.neact.org, which meets quarterly, has an annual summer conference, publishes newsletters, a journal, and has a listserv; or the **Chemistry Teacher Support Group** http://www.csun.edu/chemteach/ out of the California State University at Northridge, which hosts a nationwide listserv, can offer you more help and kindred spirits.

    For another example, join your state Safety Council. That can offer you and your school lots of safety instructional materials at discounted prices, and often maintains a substantial video library for free loans to members. AIHA may have a regional branch that meets regularly near you.
17. **People:** Always the most important resource. The point here is to get yourself into circulation and meet people who work in areas involving chemical health or safety. For instance, join your state Safety Council, or local chapter of AIHA, and serve on a committee. Volunteer for the safety committee of your local section of ACS. Youll make priceless contacts with safety and industrial hygiene professionals. You can pick their brains about whats new, what various regulations really require, etc., and they can pick yours about chemical questions. Good symbiosis! In addition, youll pick up lots of good case histories centered on safety and health, to help you make your teaching more current!

    National meetings are expensive, but regional ones are doable on a teachers budget. As always, youll get more out than you put in. They are surely the most painless form of education. In some respects, the most efficient form of communication is still the grapevine! ☺

As always, the most important thing is to get started, and to DO IT. Good luck!

The Lecture Course:

This has traditionally run as a three-hour, once-per-week evening course [in a fourteen-week semester] so that people who work days can take it. The clientele varies by the year, but consists mostly of science [primarily chemistry, biology, and environmental studies] majors and safety studies majors in equal proportions, with a smaller percentage of persons from industry, hospitals, local government, etc.

Since this paper is already too long for a web-based document, the most space-efficient way of sharing what we do is perhaps to list the lecture outline for the course as most recently run.

A bit of history: due to a Science Division rule that interdisciplinary courses could not be applied to a major in science, the coursethough interdisciplinarywas set up on the advice of senior faculty at the time, with a chemistry prefix, i.e. students receive chemistry credit for it. As I tell them on the first night, in order to legitimize their chemistry credits, 51% of the course will consist of attention to chemical hazards. That is about how it works out.

At least one semester of college chemistry is a prerequisite. Due to the minimal chemistry background of most safety majors, a section on chemical nomenclature, etc. is included. As we tell them on Night One: while we are talking about the OSHAct, the safety majors can sleep, and while we are introducing organic chemistry, the chem. majors can sleep.

Lecture Outline

Week 1: Intro; logistics; statistics; safety resources [Note: Here we spend considerable time going through an 8-page handout of where to find what information in this S&H area.]

Week 2: Workers' Comp.; the OSHAct; RTECS

Week 3: **<u>Library session</u>**: electronic literature searching;

<u>RECOGNITION</u>: Hazard warning systems;

Week 4: C<u>hemical hazards:</u> <u>flammability</u>, flash points, LFL, LEL, travel of vapors, etc.

Week 5: **Hour Exam I;** Chemical hazards, cont.: <u>reactivity</u>; violent and/or fast reactions

Week 6: Review Hr I; Chemical hazards: <u>Toxicity</u>; toxicity vs. hazard; routes of entry, modes of action

Week 7: <u>Paper topics due.</u> Review of chemical nomenclature; inorganic toxic substances, including asbestos; Organic chemicals and nomenclature, organic toxic substances;

Week 8: Spring "vacation"

Week 9: Toxics, cont.: toxic gases; Limits: PELs, TWAs, TLVs, STELs, BLVs, Cs, etc. Other toxics; modes of action; CAgens, etc.

Week 10: **Hour Exam II**; Physical hazards: High and low pressure systems, electrical systems; mechanical hazards, machine guarding, etc.

Week 11: **Bibliography and TOC due**; physical hazards, cont.: radiation: non-ionizing and ionizing; noise;

Week 12: physical hazards, cont.: heat; etc.; biohazards; <u>EVALUATION</u>: (Demo, calculations.) [Note: The demo is of various sampling devices and techniques used in industrial hygiene. The calculations piece deals with TWAs for mixtures, worst-case scenarios for spills in confined spaces, safe doses, etc. The safety majors need lots of help here, yet may well be tested on same when they seek certification as CSPs or CIHs.]

Week 13: **Hour Exam III**; <u>CONTROL</u>: Ventilation, PPE, engineering; administrative solutions; starting a safety program;

Week 14: **Term papers due.** Ergonomics; social science aspects; $ aspects; selling safety to management, etc.

Week 15: **Final Exam 6:30 - 9:00 p.m.** (or help session 6:30--7:30, exam 7:30--9:30)

There is a required term paper: topic to be chosen and **described in writing by March 11**. **Papers are due** not later than **April 29**.

The Lab Course:

This is a 3-hour lab that runs on another evening each week. This is, in some respects, thinly disguised analytical chemistry, though oriented toward industrial hygiene. Since we cant get the students out into the workplace each week, the hope is to help them achieve an appreciation for what goes on when one of their field samples arrives at a lab. For example, the absolute necessity of sending blank filters, and of telling the lab about *other* chemicals in the same work environment is emphasized.

The last lab, for which two weeks are allowed, is in fact a project, in which they must go out into the real worldsome workplace, on campus or notand do an industrial hygiene evaluation. We give them some suggestions, but many of them choose to evaluate hazards at their own part-time or full time jobs. In some cases, a micro-internship may be the project. For example, thanks to wonderful cooperation with some local employers, some students have been able to apprentice themselves to a noise control engineer in a local machine shop, a health physicist in a nuclear power plant, an OSHA compliance officer, etc. Others have evaluated solvent exposures in production facilities, formaldehyde exposures in new campus buildings, asbestos exposures in daycare centers, etc.

If I provide the initial contact for the student, that is thatstudents are to contact the person, decide sampling strategies, etc., and do the job. I am on duty in the lab during those night lab times to help them with the lab work resulting from their sampling.

List of Lab Activities

Week Activity

1. **Reading, orientation.** Learning from the materials spread out in Room nnn

[Note: This, called Resource Night, is designed to complement the session on resources done in lecture. I spread out in a big lab [with >100 linear feet of bench space] every safety and health book, pamphlet, or other publication I can dig up around the department. The large number of NIOSH publications, as one example, is quickly apparent. Students are to spend a minimum of two hours browsing the publications and taking notes for their personal professional reference. A written report of their response to the experience is the lab report.]

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2. **Industrial Hygiene Sampling:** Approximately 1-hour lecture demonstration of sampling techniques, tips, etc. A second hour of preparative work: calculations involved in IH sampling and lab work. Quantitative lab techniques illustrated too.

[No report.]

3. ["Lab 2"]: **Sampling Pumps and Sampling Trains:** calibration of sampling pumps and sampling trains, study of some important variables. [Note: this experiment is designed to show how easy it is to get the wrong answer, as well as how to calibrate an air-sampling setup. Simple permutations, e.g. putting a needle valve ahead of or behind a rotameter, sometimes yield huge differences in the measured flow rate, but telling the students that doesnt impress like their experiencing it. Soap bubble flowmeters [inverted burets] are used for calibration.

4. **Asbestos Fibers in the Air [Microscopy]:** a NIOSH method, using phase-contrast microscopy. We have been fortunate enough to get some used NIOSH PAT [Proficiency in Analytical Testing] filters, whose counts

are known. We create fictitious sampling times and rates, for each, and provide those numbers to the students, who can then calculate the exposure and compare it to OSHA and NIOSH limits.

5. **Chromium in a Plating Tank [Spectroscopy]**
[Note: this is a thinly-disguised intro to Beers law.]

6. **Solvent Vapors in the Air I: Desorption Efficiency [Gas Chromatography]**
[Note: this uses charcoal tubes spiked with MEK; the amount of MEK recovered is determined by GC. Breakdown products in the MEK provide an abject lesson in identification difficulties in GC-FID.]

7. **Solvent Vapors in the Air II: Preparation of a Dynamic Standard; Collection Efficiency**
[Note: More GC, but with the added feature of generating a known concentration of MEK in air (cylinder N_2) using a diffusion tube (made from a broken pipet). Comparing the determined amount of MEK with that passed through the charcoal tube provides reinforcement of the difference between absolute amounts and concentrations, as well as sometimes eye-opening results.]

8. **Lead in the Work Environment [Atomic Absorption Spectroscopy]**
[Note: Here I spike 37-mm membrane nitrocellulose filters with known amounts of a lead standard. Students are provided with sampling times and rates for their filter (each gets a different one). The filters are digested in nitric acid per NIOSH analytical method, diluted quantitatively, and analyzed by AAS.]

9. **Special Project:** from the list presented in lab, or one of your own.
[Note: This has been described in more detail above.]

A <u>written proposal</u> must be submitted no later than the mid-point of the course [i.e. 00/00/00]. The proposal should include the a) title and b) purpose of the project, c) as detailed a plan of action as possible, and d) a list of resources needed, e.g. instrument(s), equipment, supplies, chemicals, help, etc.