Chemical And Radiation Protection

Lab Safety Spectrum

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UW - Madison Safety Department Chemical and Radiation Protection
30 N. Murray St. 262-8769 http://www.fpm.wisc.edu/safety

Radioactive Materials License No. **25-1323-01** Help Line 265-5518

Radioactive / Chemical Waste Collection

Labs have begun moving into the new BioTech Addition. This may produce a bit more work load for our waste collection efforts. If your lab is located to the West of Walnut Street (e.g., CSC, Waisman, Rennebohm, etc.), we may end up picking up your waste on Wednesday morning instead of Tuesday afternoon. If we formally change the schedule to reflect this, the change will be indicated on our web site.

Radioactive:
http://www.fpm.wisc.edu/safety/Radiation/pkup.html
Chemical:
http://www2.fpm.wisc.edu/chemsafety/oshmm.htm

Chromium-51 (^{51}Cr)

Several research labs use chromium-51 (^{51}Cr) in their research projects. Workers in these labs have no difficulty detecting ^{51}Cr with whatever type of survey meter (e.g., GM or iodine probe) they have at hand. We have not yet begun calibrating meters for ^{51}Cr, but we are considering adding that isotope to our list. Chromium-51 is not an easy isotope for which to calibrate. The table shows how radiation is emitted in a ^{51}Cr decay:

^{51}Cr, electron capture decay, $T_{½}$ = 27.7 days		
Radiation Type	Energy (keV)	% emitted
Auger-L (electron)	0.47	144.7
Auger-K (electron)	4.38	66.9
X-ray L	0.5	0.33
X-ray $K_{\alpha 2}$	4.94464	6.59
X-ray $K_{\alpha 1}$	4.95220	13.1
X-ray K_{β}	5.43	2.62
γ-ray	320.076	9.83

Chromium-51 decays by electron capture. For each decay, 1.447 L-shell electrons are ejected from their orbits with an energy of 0.47 keV and 0.669 K-shell electrons are ejected with an energy of 4.36 keV. These electrons are not detectable with survey meters. The K-shell electron (4.38 keV) is detectable in LSC since it is a bit less energetic than a hydrogen-3 beta particle (maximum energy 18.7 keV, average energy ~ 6 keV).

There are also some low-energy characteristic x-rays from the L-shell (at 0.5 keV, 0.33% of the time) and three from the K-shell (at 4.94, 4.95, and 5.34 keV; 6.6, 13.1, and 2.6 % of the time, respectively). There is also a gamma-ray at 320 keV emitted 9.8% of the time.

As noted, the 0.47 keV Auger electron is not detectable and the 4.38 keV Auger electron is only detectable in a liquid scintillation counter. Cr-51 efficiency when counted in the tritium (H-3) window is about 25% (for an energy region 2 - 18 keV) or 40% (for an energy region 0 - 18 keV) (remember this electron is only 66% abundant).

The low-energy x-rays average around 5 keV and 22.5% abundance. They are not very penetrating. In an unshielded sample (e.g., contamination or open vial), they can be detected by a thin window GM with an efficiency of about 0.2% (we know they are predominately the x-rays because a 0.1 mm Al plate reduced the count by 95%) leaving only the 320 keV gamma ray (efficiency for this with a thin-window GM is about 0.01%).

The high-energy gamma (320 keV at 10% abundance) can be detected with an iodine probe (i.e., scintillation detector) at about 0.2% efficiency (we know these are the gamma rays because the count rate did not decrease with the insertion of 0.1 mm Al attenuator.)

Why can you detect Chromium-51 in a vial with a GM if you can not detect the low-energy (~5 keV) x-rays? It's the numbers. Chromium-51 normally comes in a 5 mCi vial. Remember, 1 mCi = 2.22×10^9 dpm. If only 10% emit the 320 keV gamma rays, that is 222,000,000 gamma rays per minute. If your thin-window GM has an efficiency of 0.01% (0.0001), then it can still detect 222000 cpm (of the 5 mCi). Even 50 microcurie would produce about 2220 cpm on a G-M.

So, if you are using chromium-51, know that efficiency with any type of survey meter is very low, but LSC counting will give you precise results.

Pregnancy Surveillance

Epidemiological studies have suggested the embryo / fetus is more sensitive to effects from high (> 10 rem) radiation doses than adults. Therefore lower radiation dose limits apply to the fetus of a pregnant radiation worker than the mother; 500 mrem for the fetus vs. 5000 mrem for the mother. This effectively limits the radiation exposure of a pregnant radiation worker to 500 mrem.

The University's Pregnancy Surveillance Program is a voluntary program. Together with the pregnant worker, the Safety Department will review her radiation exposure history, her lab's workload (type and quantity of radionuclides), and, if appropriate, provide suggestions to reduce exposure ALARA and well below the 500 mrem. To inquire into this program call the Safety Department (2-8769) and ask for Sally Rowe or email radpro@fpm.wisc.edu and we will contact you.

Is it Safe?

There is a stressful scene in the movie "Marathon Man" staring Dustin Hoffman (as Babe) and Laurence Olivier (as Dr. Szell). Babe is a graduate student (and obsessive runner) who is drawn into a mysterious plot involving his globe trotting brother, his European girlfriend and a Nazi war criminal in hiding. In the memorable dentist torture scene, Szell uses his dental instruments for sadistic oral surgery to torture and extract information from Dustin Hoffman. Szell believes Hoffman is working with his enemies to prevent him from retrieving his cache of diamonds and wants to know if he can safely get them. He repeatedly asks Babe the question: "Is it safe?"

Many workers at the UW ask the same question, "Is it safe?" as if safety was a "yes" or "no" condition, where one can move up to a line that separates a safe state from an unsafe state. The fact is that safety is a continuum based upon the conditions at that time.

There are many similarities between driving a car and working safely in a lab. Both are conditional. Most days driving 30 mph on University Ave. is more than safe, but on snowy or icy road conditions, that speed may be much too fast. Work in a lab can be similar. A procedure safely conducted using 1 gm may be unsafe using 10 gm. It is potentially more hazardous to weigh out a pure substance to make a solution than to buy the solution premixed. Thus, conditions which affect the safety of lab work include the agent / compound being used, concentration of the compound, the ventilation in the work area, protective equipment being used, etc.

While there is no hard and fast rule about safety and protection provided in each situation, the table on the next page provides a first estimate of protection factors against internal deposition of aerosols, dusts, vapors, etc. Assuming that normal lab operations have a protection factor of 1, then just keeping stock solutions in storage is 100-times safer.

Performing very simple wet operations is 10-times safer than normal operations. Whereas, performing complex, wet operations with risk of spills or simple dry operations is only 0.1-times as safe. The most hazardous operation would be one involving dry / dusty procedures.

Modifying Factors

Type of Operation	Modifying Factor
Storage (stock solutions)	x 100
Very simple wet operations	x 10
Normal operations	x 1
Complex wet operations with risk of spills and simple dry operations	x 0.1
Dry and dusty operations	x 0.01

A good example of these factors can be found in the use of ethidium bromide. This is a powerful mutagen widely used in biochemical research labs for visualizing DNA. The most risky phase of use is when it is being transferred as a powder from one container to another or while making ethidium bromide solutions. As can be seen, dry operations are 100-times riskier than normal operations. A safer situation would be to buy the ethidium bromide as a premixed solution.

Many labs use compounds called Particularly Hazardous Substances. These include select carcinogens, substances with a high acute toxicity (e.g., oral toxicity < 50 mg/kg), and reproductive toxins. The Occupational Safety and Health Administration (OSHA) requires (29 CFR 1910.1450) that persons who work with these substances have "provisions for additional employee protection .... which include:

A) Establishment of a designated area
B) Use of containment devices (e.g., fume hood / glove box)
C) Procedures for safe removal of contaminated waste
D) Decontamination procedures"

Appendix D of our Safety Guide discusses procedures for working with Particularly Hazardous Substances (PHS). Essentially, there is a review form (included in the newsletter and available for download from our web site: http://www.fpm.wisc.edu/chemsafety/forms.htm) The form needs to be approved before work with the substance can begin [29 CFR 1910.1450 (e)(3)(v)]. We see this review process as going in at least two routes, depending upon specific work:

1. For Particularly Hazardous Substances which are known or probably human carcinogens (as identified by the International Agency for Research on Cancer (IARC) -- see Annex D-1 to Appendix D), for Reproductive Toxins (see para D.2) and for Substances with a High Degree of Acute Toxicity (see Para D.3), and for work which has a Modifying Factor of 1 or less (e.g., normal operations, complex wet operations with risk of spills and simple dry operations, and dry and dusty operations) we believe the procedure should be reviewed by chemical safety specialists at the Safety Department.
2. For Particularly Hazardous Substances which are possible human carcinogens (as identified by the IARC) and for work which has a Modifying Factor of more than 1 (e.g., very simple wet operations, storage) we believe that review can be conducted by the lab's / department's Chemical Hygiene Officer.

The review would be performed by the lab completing a Particularly Hazardous Substance Use Approval Form (see para D.4) for each such use. This form would only need to be completed one time and then filed with the lab's Chemical Hygiene Plan (see Appendix C of Safety Guide) as long as the procedure involving the PHS does not change. Depending upon the type of PHS and operation envisioned, the form would either be FAXed to Chemical and Radiation Protection (2-6767) or approved locally (see above).

While this review procedure is a little sketchy at present, except for the "Normal operations" category (Modifying Factor = 1), this is the concept that the University Chemical Safety Committee thought would be the most cost-effective process to assure safety and compliance. It is also the procedure that the Chancellor's Executive Team, one of whose function is to review safety, security and compliance on campus, is studying.

Training:

Chemical and radiation safety training is available weekly. There are two types of schedules; Chem AM classes have the chemical safety class beginning at 9:30 AM and the radiation safety class beginning at 12:30 PM. Rad AM classes have radiation safety classes beginning at 8:30 AM and the chemical safety class beginning at 1 PM. The schedule of these classes through September is:

Chemical AM Chemical Safety Radiation Safety	**Start Time** 9:30 AM 12:30 PM	September 9, 15, 22; October 6, 15, 21; November 12, 18, 24; December 9, 13
Radiation AM Radiation Safety Chemical Safety	**Start Time** 8:30 AM 1 PM	September 27; October 27; December 3

All training classes are held in Union South. No sign-up is needed; a quiz documents training. Booklets for either class can be picked up at our Annex, Room 62, Biochemistry (11 AM - 2 PM). A complete listing of classes is found at http://www.fpm.wisc.edu/safety

Transportation: If you send out or sign for hazardous material (i.e., red-bordered shipping paper), you must have received a formal training class within the past 3 years. Radiation, Biological and Chemical Safety each offer classes to satisfy this requirement. The Chemical Classes are held at Union South on the following dates / times: September 16 (9 AM - 1 PM); October 13 (11 AM - 3 PM); November 2 (9 AM - 1 PM) and December 10 (9 AM - 1 PM). Call Biological Safety (3-2037), Chemical Safety (2-1524) or Radiation Safety (2-1524) to enroll in a class.

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