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Radiation Safety Guide

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MIT EHS
ENVIRONMENT · HEALTH · SAFETY

Delegation of Authority

MIT has a standing institute **Committee on Radiation Protection** to oversee all uses of radiation at the Institute and its associated off campus locations. They give the RPP authority to stop any experiment or process involving radiation that is deemed unsafe.

Dose Limits

Whole Body	(5 rem)
Lens of Eye	(15 rem)
Extremities	(50 rem)
DPW*	(0.5 rem)
General Public	(0.1 rem)

*Declared Pregnant Worker

Most MIT radiation workers receive less than 10 mrem each year from occupational exposure!

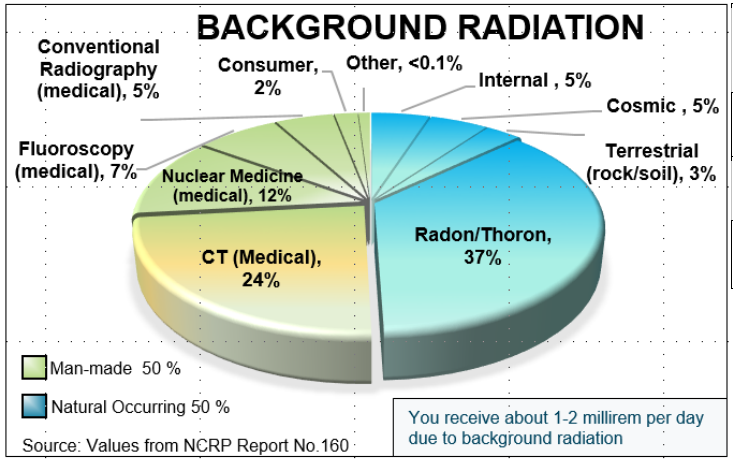
Dose Monitoring

Personal Dosimetry

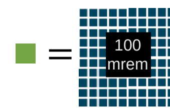
Anyone likely to receive 500 mrem (10% of the annual dose limit) is required by regulations to wear a dosimetry badge. Convenience dosimetry may be issued at the request of the researchers not likely to receive 10% of the annual dose.

At MIT, you will be assigned a dosimeter if you're working with P-32 or gamma emitting isotope.

Background Radiation



	Living next to a nuclear power plant	<1 mrem		Cosmic Radiation (Denver)	80 mrem
	Eating 1 banana a day	3.5 mrem		Radon in Avg. Home	228 mrem
	Terrestrial Radioactivity	21 mrem		Whole Body CT (1-time)	1000 mrem
	Cosmic Radiation (sea-level)	30 mrem		Radiation Worker Limit (Whole Body)	5000 mrem



Annual radiation dose comparison.
Data from epa.gov/radiation/radiation-sources-and-doses
Inspired by xkcd.com/radiation

Authorization Process and Ordering RAM

Authorization to possess RAM

1. Complete the application for "Authorization to Possess and Use Radioactive Materials" and forward to RPP.
2. Upon RPP review and approval, the Project Supervisor will receive a copy of the Authorization with designated number.
3. If any changes need to be made to the Authorization, at any time, the Project Supervisor must apply in writing for an amendment, to the RPP.

Experimental Protocols

1. Protocols should be written to include all safety precautions taken that pertain to the use of **radioactive material (RAM)** and the user.
2. To avoid an overexposure and serious injury, all experiments involving RAM must be conducted according to protocols submitted to RPP.
3. Any change in protocol must be approved by RPP prior to implementing.

Ordering Rad Material

1. Include the words "Radioactive Material" and the Project's Authorization number on the purchase requisition.
2. In addition to the supplier's catalogue number, specify the radionuclide and amount of activity wanted.
3. For the RAM being ordered, provide an accurate activity of the current inventory, of that isotope, in the lab.

Securing Radioactive Material

1. Once delivered by RPP Tech, process package according to the Orange Sticker.
2. Secure RAM in RPP approved storage locations and record received stock material into logs.
3. **NEVER** leave stock vials or RAM packages unattended or unsecured.
4. If an experiment involving RAM must be left unattended, ALWAYS label it with isotope, activity, date, and immediate contact info.

Common Radioisotopes in Laboratories

Isotope	Type	Half Life	Detection Method	Considerations
C-14	Beta	5730 years	GM (low efficiency), LSC	Long half-life means potential long-term contamination problem.
PET Isotopes: Cu-64, F-18, Zr-89	Beta/ Gamma	12.7 hours, 110 minutes, 78.41 hours	GM	Work behind shielding, handle stock and vials in shields or with remote handling tools. Shielding should be comprised of plastic FIRST, with a lead or foil backing. se syringe shields and always store stock and filled syringes in lead pigs.
Fe-55	Gamma, X-ray, Auger Electrons	2.7 years	NaI or LSC	Handheld detectors have low efficiency for Fe-55, work cautiously to avoid contamination.
H-3	Beta	12.6 years	LSC (Wipe test)	Low energy, hard to detect, long half life.
I-125	X-ray, Gamma	60 days	NaI	Thyroid hazard, bioassay may be required
P-32	Beta	14 days	GM	Creates x-ray hazard when shielded by lead
P-33	Beta	25 days	GM (pancake). LSC	Low amounts of P-33 cannot be detected with GM. Wipe tests counted on LSC should be done regularly.
S-35	Beta	88 days	GM (pancake), LSC	Possible volatility hazard , work to be performed in Radiation designated hood.

Handling RAM

Only workers **registered with EHS-RPP** can handle RAM. **Personal Protective Equipment (PPE) must be worn.** Minimum requirements: Lab coat, gloves, safety glasses, long pants, closed toed shoes, and dosimetry when assigned. When handling high energy beta or gamma radiation, use **handling tools and work with material behind a shield when possible.** Take out only what you need and **secure stock immediately**.

Radioactive Waste

Solid radioactive waste must be segregated by half-life: <20 days, 20-120 days, >120 days

Water soluble liquids can be disposed of in designated sinks within allowable limits.

Non-soluble liquids must be collected in designated jars/containers.

All waste disposals must be recorded!

For a RAM waste pickup go to (Link to waste pickup site) and submit your request.

RAM Inventory/Use

Each lab is required to record all RAM "transactions" and know how much radioactivity they have on hand at all times.

Always record how much activity was used, what remains in the vial, and what was discarded as waste.

Radioactivity in your waste bin must be counted in the lab's inventory!

Calculations

Basic decay: **A** =activity, $\mathbf{A_0}$ =initial activity **t** =time elapsed ,**T** =radioactive half-life. $A = A_0\, e^{-\frac{\ln(2)t}{T}}$

Inverse Square Law: $\mathbf{R_1}$ is initial dose rate at the initial distance $\mathbf{d_1}$, $\mathbf{R_2}$ is the dose rate at distance $\mathbf{d_2}$.

$$R_2 = R_1 \left(\frac{d_1}{d_2}\right)^2$$

Radioactive Contamination

Cleaning up a Radioactive Spill

1. ***Announce*** a spill has occurred so others can stay away from area. For a major spill (> than 10 uCi) or H-3, contact RPP.
2. ***Survey*** yourself and lab mates clothing, shoes, and person. Define the boundary of the spill using your survey meter, and clearly mark the area.
3. ***Clean*** the spill using a cleaner and paper towels, working your way toward the center of the spill, surveying frequently.

You can ALWAYS contact RPP anytime (24/7) for assistance with any spills or contamination! Dial FIXIT from any MIT campus phone after hours.

Performing a Wipe Test

Wearing gloves, take a clean smear to the potentially contaminated area, wiping in an "S" pattern.

For H-3, count on a Liquid Scintillation Counter. All other isotopes, hold wipe up to the window of an detector, such as a GM (not touching the probe).

Determining Background: Use same method as above on a known clean surface.

Results greater than 2X your determined background is considered contaminated and needs to be cleaned.

9 Traits of a Positive Safety Culture

1. Leadership Safety Values and Actions
2. Problem Identification
3. Personal Accountability
4. Work Processes
5. Continuous Learning
6. Environment for Raising Concerns
7. Effective Safety Communication
8. Respectful Work Environment
9. Questioning Attitude

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Definitions

Absorbed Dose: The energy imparted per unit mass or irradiated material. Measured in rad, where 1 rad equals 0.01 Joules/kg or absorbing material. The SI unit is the Gray (Gy).

Note: 1 Gy = 100 rad = 1 J/kg

Alpha Particle (α): A charged particle emitted from the nucleus of an atom having a mass and charge approximately equal to a helium nucleus. ***LOW Penetration ability***.

Beta Particle (β): Charged particle emitted from the nucleus of an atom, with a mass and charge equal to that of an electron. ***MODERATE penetration ability.***

Dose Equivalent: The product of the absorbed dose and the appropriate quality factor for the type of radiation measure in **rem.** The SI unit is Sievert (Sv).

Note: 1 Sv= 100 rem.

Exposure: A measure of the ionization produced in *AIR* by X or Gamma radiation. Measured in **Roentgen (R),** where 1 R = 2.58 x 10^4 Coulombs per kilogram of dry air at STP.

Gamma Ray (γ): Short wavelength electromagnetic radiation of nuclear origin. ***VERY high penetration ability***.

Ionizing Radiation: Electromagnetic (X ray and gamma) or particulate (alpha, beta) radiation capable of producing ions or charged particles.

Radiation: Energy transmitted as electromagnetic waves or particles from a source.

Radioactivity: The property of certain nuclides of spontaneously emitting particles or gamma radiations or emitting X-rays following orbital electron capture. Measured units are Curies (Ci) or SI unit, Becquerel's (Bq). 1 Bq = 1 disintegration per second. 1 Ci = 3.7x10^{10} Bq.

RAM: Radioactive Material

X-Rays: Short wavelength electromagnetic radiation of extra-nuclear origin. ***VERY high penetration ability***.

Performing a Survey

Before and after working with radioactive materials, perform a survey of the area to ensure your area is clear of contamination.

- Check calibration date on detector.
- Check battery.
- Check response using check source on instrument.

Measure the background count in an area known to have no radiation.

Scan your work area (or anywhere RAM was used) by holding detector face ~1 cm above surface moving slowly (about 5 cm/s)

Notify RPP if meter reading is greater than 2 mR/hr

ALARA

As Low As Reasonably Achievable

Minimize Time | Maximize Distance | Use Shielding | Plan ahead | Remember to Survey BEFORE and AFTER

Shielding

Alpha Particles: Stopped by a sheet of paper or dead skin layer.

Beta Particles: Stopped by a sheet of plastic or other low density material. (Do **NOT** use lead, this creates an X-ray hazard!)

Gamma/X-Rays: Stopped by lead, concrete, or other approved high density materials. **The thickness of the shield is dependent on the energy of the radiation being shielded.**