



THE UNIVERSITY OF
CHICAGO

**Office of
Research Safety**

**University of Chicago
Office of Radiation Safety
Radiation Safety Manual**

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Table of Contents

Radioactive Material User Training	4
Radiation Safety Training Courses	5
Radiation Physics – “The Basics”	6
Radiation in the Environment	8
Units of Measurement	9
Half-Life	9
Isotope Decay Chart.....	11
ALARA and Principles of Radiation Safety	12
Radioactive Decay and Radiation Emission	13
Radiation Shielding in the Laboratory	15
Safety Rules and Regulations	16
Research Laboratory	16
General Rules for the Safe use of Radioactive Material	16
Personal Protective Equipment	16
Food Handling and Storage	17
Occupational Exposure Limits.....	18
Dosimetry.....	19
Radiation Dosimeter Distribution and Pick-up.....	20
Individual Radiation Exposure Investigational Limits	21
Security	22
Radioactive Material Labels	22
Transport/Transfer of Radioactive Materials	23
Radioactive Material Procurement	24
Radioactive Material Procurement - Ordering Process	24
Authority and Responsibility	26
Radionuclide Receipt and Usage	27
Receipt and Disposal Record Instructions	27
Waste Handling.....	30
Radioactive Waste Management.....	32
Stock Vial Disposal.....	33
Liquid Scintillation Vial Disposal	35

Survey Instruments	36
Required Radiation Detection Instruments	36
Geiger-Mueller Detector	36
Detector Efficiency	37
Survey Instrument Calibration	38
Survey Instrument Repairs	38
Preparing to Use a Geiger-Mueller Survey Meter	39
Survey Meter Battery Test	39
Survey Meter Operational Check	40
Procedure for Completing the Operational Check	40
Reading the Survey Meter Dial	41
Effective Use of a Survey Meter	42
Sodium Iodide (NaI) Scintillation Detector	43
Liquid Scintillation Counters	43
Mandatory Radiation Surveys	44
Post-experiment Survey	44
Weekly Laboratory Survey	44
Survey Documentation	46
Decontamination and Corrective Actions	47
Preparing Your Experiment	49
Additional Precautions for Specific Radioactive Substances	49
Emergency Procedure	50
Appendix A: IEMA Emergency Procedure	51
Appendix B: Waste Instruction Labels	52

List of Figures

Fig. 1: The Electromagnetic Spectrum	6
Fig. 2: Ionization Process.....	7
Fig. 3: Effects of Ionization on a Cellular Level	7
Fig. 4: ‘Caution Radioactive Materials’ Posting.....	7
Fig. 5: Annual Background Radiation Exposure	8
Fig. 6: Radiation Decay Chart	10
Fig. 7: Radiation Safety Principles	12
Fig. 8: Types of Ionizing Radiation	13
Fig. 9: Basic Properties of Commonly Used β - Emitting Radionuclides	14
Fig. 10: Shielding Ionizing Radiation	15
Fig. 11: Whole Body Dosimeter and Extremity Ring.....	19
Fig. 12: “Caution Radioactive Materials” Label.....	22
Fig. 13: Receipt and Disposal Record Example	29
Fig. 14: Waste Manifest Examples	31
Fig. 15: Radioactive Aqueous Waste Drain Disposal Record	34
Fig. 16: Survey Meter Display.....	41
Fig. 17: Survey Meter Example	41
Fig. 18: Weekly Laboratory Survey Form.....	45
Fig. 19: Corrective Action Threshold	48

Radioactive Material User Training

Radioactive Material (RAM) User Training is intended for all students, volunteers, and employees of the University of Chicago who will actively use radioactive material in a clinical or research laboratory setting. It may also serve as Awareness Training for non-RAM users who work in areas where radioactive material is present. After attending today's lecture, successfully completing the knowledge assessment, and submitting the New User Amendment and Training Certification Form (from the handout), you will be authorized to work with RAM in the designated areas of your respective Principal Investigators (PI). Our office will send an updated list of radioactive material users for your PI's protocol when we receive the New User Amendment and Training Certification Form. Completed forms should be submitted to the Office of Radiation Safety via delivery to our office, fax or interoffice mail.

University of Chicago
Office of Radiation Safety
Business Hours – 8:30 AM to 12:00 PM and 1PM to 5PM Monday through Friday
Room M-031A (basement of Billings hospital, next to the cafeteria)
Mail Code: MC 2106
E-mail: radsafety@uchicago.edu
Phone: 2-6299
Fax: 2-4008

All of the forms and documents discussed in the lecture today, as well as Radiation Safety Policies and other information relevant to the Radiation Safety program can be found at our website:

<http://researchsafety.uchicago.edu/page/radiation-safety-forms>

Radiation Safety Training Courses

The Office of Radiation Safety offers several training courses for those working with or around radiation. RAM User training is offered biweekly and required for all employees who intend to work with radioactive materials. Attendance is mandatory regardless of previous experience. Users attend a live training course initially and complete an Annual Refresher training thereafter. Annual Refresher Training involves reviewing the Radioactive Material User Refresher Training (Course Number RAD-002: Radioactive Material User Refresher) slide presentation on the University of Chicago EHSA Learning System and completing the knowledge assessment.

Individuals working in a laboratory who will not be handling RAM may complete a Radiation Safety Awareness Training (Course Number RAD-004 Radiation Safety Awareness). This training presentation is available on the University of Chicago EHSA Learning System.

Non-RAM users are welcome to attend the RAM User training if the PI so desires.

The Office of Radiation Safety offers a course for Radiation Safety Laboratory Designee Training (Course Number RAD-003: Radioactive Material Laboratory Designee) slide presentation on the University of Chicago EHSA Learning System. Each PI will assign at least one RAM User to be an official contact person and radioactive materials manager for the laboratory. If you wish to attend the one-time training to be eligible for Laboratory Designee status, contact the Office of Radiation Safety.

Specific equipment utilizing ionizing or non-ionizing radiation requires additional training. Individuals wishing to use cell or animal irradiators must complete a background check and attend an Irradiator Training course. The Office of Radiation Safety also administers Laser Safety Training for users of Class 4 and Class 3b lasers and a Laser Awareness training for non-users available on the EHSA website. For more in-depth laser training, please contact the Office of Radiation Safety.

Radiation Physics – “The Basics”

In order to safely work in an environment where radioactive materials are used, it is important to understand some basic concepts of radiation physics. Many of these may already be familiar to you, especially if you have prior RAM experience. We intentionally present this material in a simplified fashion, with the goal of providing a review for experienced users and a base of knowledge for new users. Please contact the Office of Radiation Safety if you have more specific questions about radiation physics or would like more extensive information and materials.

It is important for a Radioactive Material User to be able to differentiate between the terms **radiation** and **radioactive material** as they are not interchangeable! For the purposes of an approved Radiation Worker at the University of Chicago, **radiation** can be defined as energy that radiates from an object, traveling through space in wave or particle form. In our everyday environment, we are exposed regularly to both non-ionizing radiation and ionizing radiation. The University of Chicago’s Radiation Safety policies are mainly concerned with the safe use and security of radioactive materials, ionizing radiation, as well as safety and compliance with regulations.

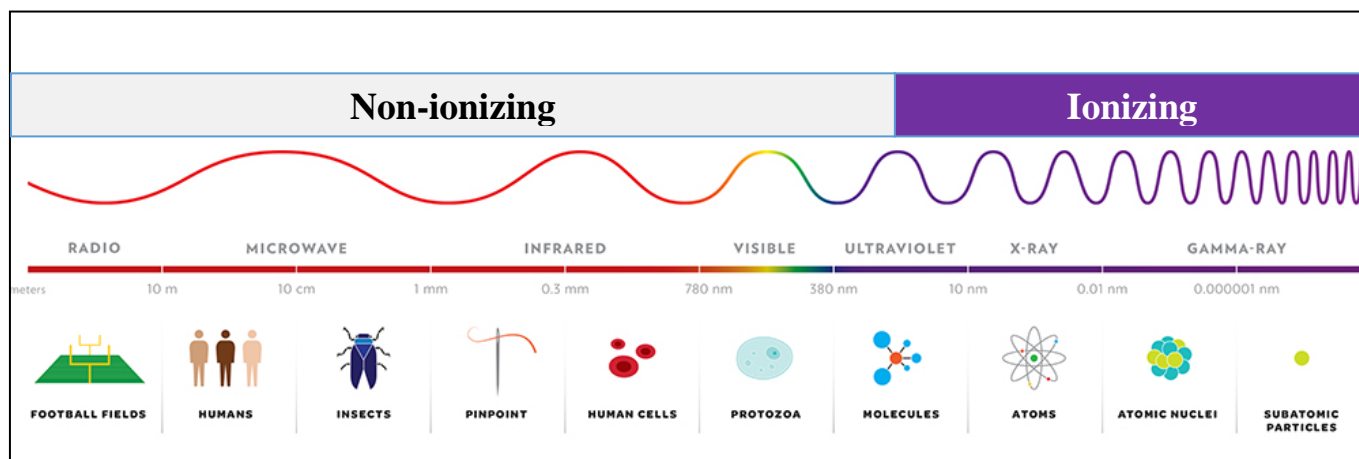


Fig. 1: The Electromagnetic Spectrum

Ionizing radiation is harmful to humans because of the potential for ionization of the tissues at the cellular level. Removal of an electron from the atom may result in some biological effect such as the disruption of cell metabolism, cell division, or even death of the cell altogether. The prevention of any biological effect due to ionizing radiation is the ultimate goal of radiation safety.

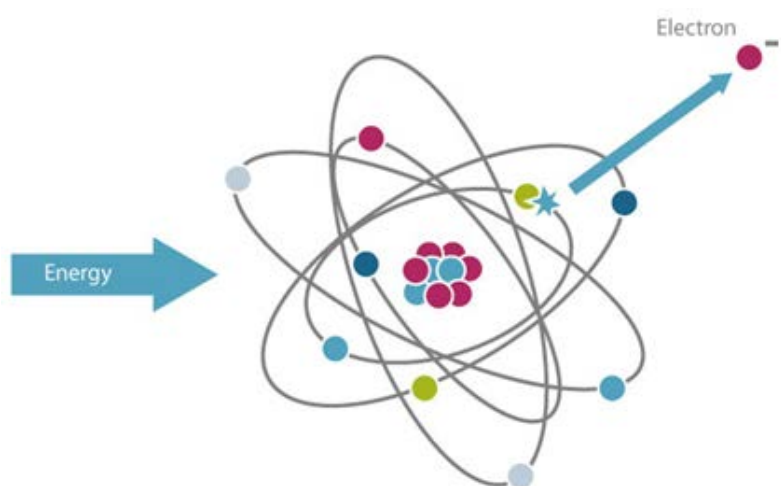


Fig. 2: Ionization Process

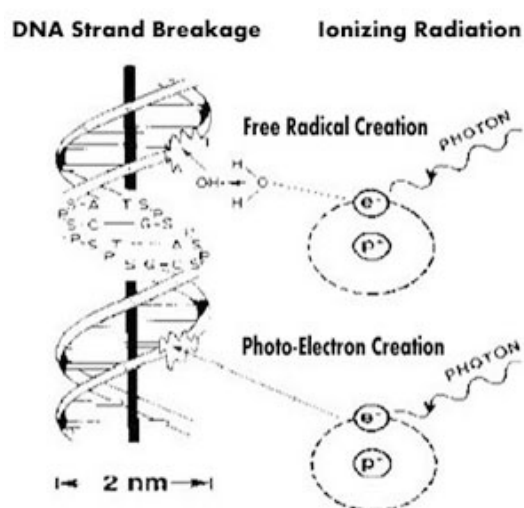


Fig. 3: Effects of Ionization on a Cellular Level

We have defined **radiation**, so let us contrast that with **radioactive material**. In the laboratory, this will include stock vials of radiolabeled nucleotides, amino acids, antibodies, etc. It will also describe any item that comes in contact with radioactive material, such as labeled samples, contaminated glassware or equipment, radioactive waste, and so on. Radioactive material is always signified by the universal symbol of the trefoil, usually magenta or black in color on a yellow background.



Fig. 4: 'Caution Radioactive Materials' Posting

Radiation in the Environment

We are constantly being exposed to naturally occurring and man-made sources of radiation in our everyday environment. Food, water, soil, the air we breathe, and various medical procedures all contribute to our annual exposure. It should be noted that the average annual exposure for a person living in the United States, 625 mRem, is significantly higher than what a radiation worker might receive on the job at the University of Chicago. This is an excellent way to show that when radioactive material is handled safely within the guidelines we will prescribe in this training session, the workers' exposure to radiation will be statistically insignificant. You are probably safer in your laboratory than you are out in the sunlight! Cosmic radiation levels will vary with altitude – the closer you are to outer space, the greater the exposure you will receive. Frequent fliers should expect a greater annual exposure based on the amount of time they spend at higher altitudes, the average exposure from the cross-country flight (i.e. from New York City to Los Angeles) is about 3-5 mRem.

Similarly, the exposure from terrestrial sources of radiation, such as uranium, radium and thorium in heavy metals, is determined by your geographic location and concentrations in the soil.

Many of the foods we eat and products we consume will have small concentrations of naturally occurring radiation, which also contribute to our annual exposure. Bananas, nuts, oils, and water are the most common culprits. Diagnostic procedures such as X-rays or nuclear medicine studies will also add to exposure levels. Even the fallout from decades-past nuclear weapons testing still contributes to naturally occurring radiation exposures.

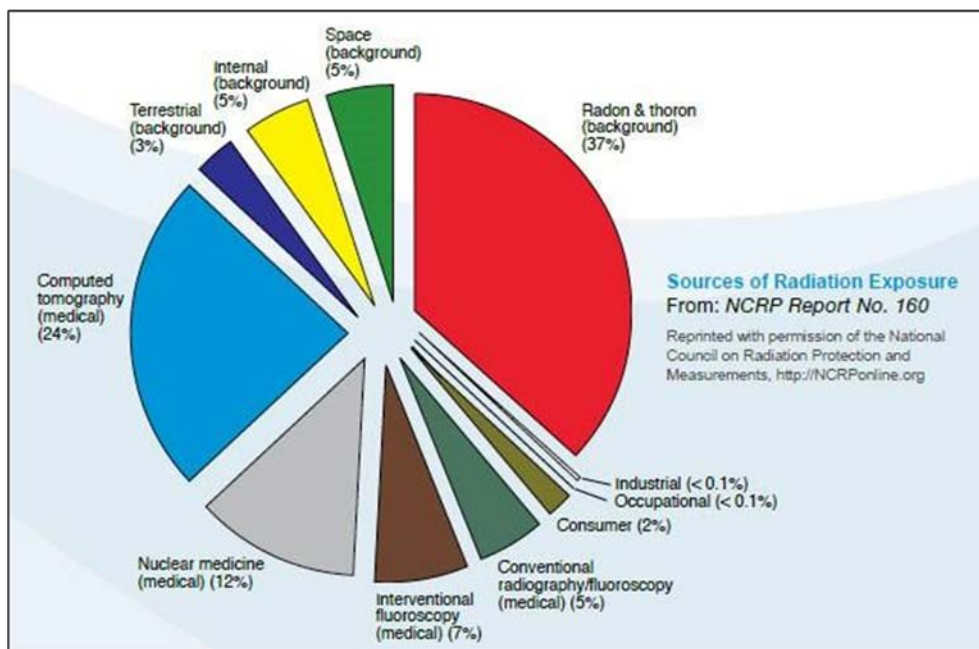


Fig. 5: Annual Background Radiation Exposure

Units of Measurement

We now present a brief review of the units of measurement that you, as a radiation worker, will need to be familiar with here at the University of Chicago. They are simplified to the extent that you need only have an understanding of what they represent and how to interpret or record the appropriate values. As a function of everyday radiation safety activities, you will not be asked to calculate exposure rates or manipulate data to quantify remaining activities. If you would like more extensive information on radiation physics, you may consult the Radiation Safety manual or contact one of the Health Physicists in the Office of Radiation Safety.

The curie (Ci) is simply a quantification of how much radioactive material is present. Most of the radioactive material sources you will encounter are in microcurie (μCi) amounts. One curie represents 3.7×10^{10} disintegrations (or emissions) per second. **Dose** refers to the amount of radiation absorbed into matter. In our case, we are concerned with radiation absorbed by human tissue, which is recorded in units of Rem (Roentgen-equivalent man) or mRem.

You will often see values recorded in mR/hr (milli-Roentgen/hour). This represents an estimate of the dose to human tissue over a period of time. For most radioactive isotopes, we are required to measure exposure rates from radioactive material with the appropriate survey meter and record those values in mR/hr.

For some isotopes, we will record values in cpm (counts per minute) and dpm (disintegrations per minute). The cpm represents the actual number of disintegrations or radioactive particles detected by the survey meter (counts) in one-minute time. Therefore, the actual number of disintegrations per minute is equal to cpm divided by the efficiency of the instrument.

$$dpm = \frac{cpm}{\text{efficiency}}$$

An instrument having 50% efficiency will only detect one of every two disintegrations. A recorded value of 20 cpm reflects an actual result of 40 dpm ($20 \text{ cpm} / 0.50 \text{ meter efficiency}$).

Half-Life

A half-life is the time in which one-half of the activity of a particular radioactive substance is lost due to radioactive decay. Measured half-lives vary from millionths of a second to billions of years. Half-life is often referred to as the physical or radiological half-life.

The half-life ($t_{1/2}$) obeys this relation:

$$t_{1/2} = \frac{\ln 2}{\lambda}$$

where λ is the **decay constant**, a positive value used to describe the rate of exponential decay. Each isotope of an element that is radioactive will have its own specific decay constant value.

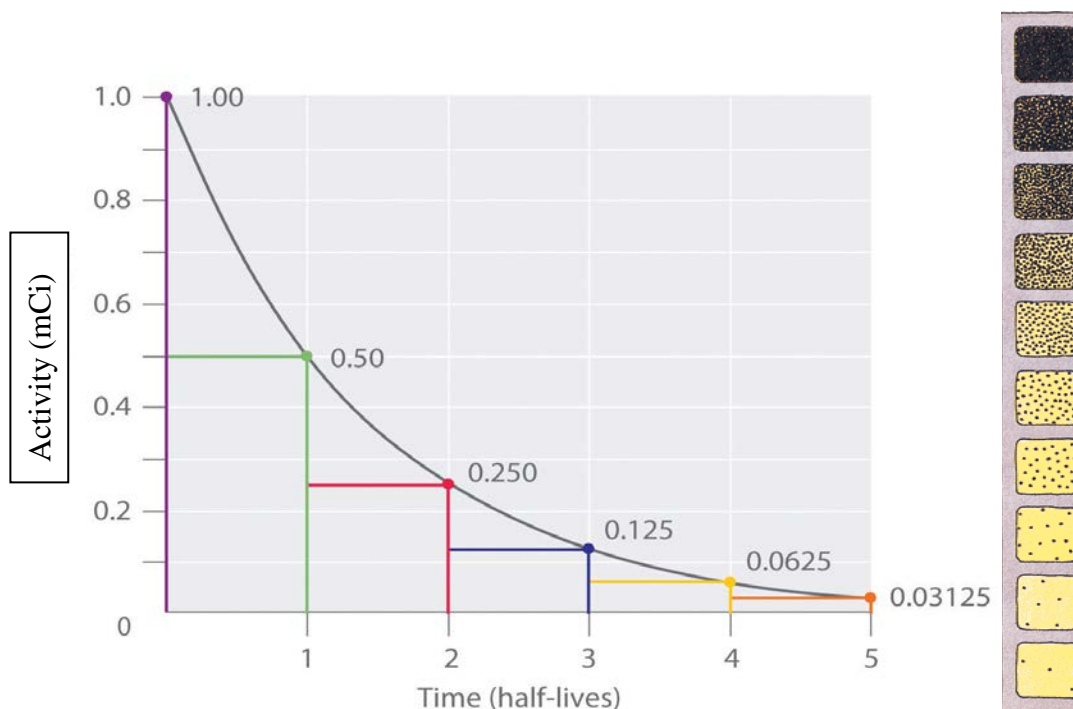


Fig. 6: Radiation Decay Chart

Radioactive material users at the University of Chicago will not be asked to perform decay calculations to determine remaining activities for quantification or inventory purposes. It is useful, however, for the user to be familiar with the half-lives of the radioactive materials used in the laboratory. This will allow them to assess the viability of the materials for experimental use.

To calculate the current activity **A** of an isotope having a half-life **T**, use the formula

$$A = A_0 \cdot e^{(-\ln 2 \cdot t/T)} \quad \text{OR} \quad A = A_0 \cdot e^{-\ln 2 \cdot t/T}$$

Where **A₀** is original activity (on assay date) and **t** is time elapsed since assay date.

Example: Dr. Acula has an unused vial containing 0.5 mCi of S-35 methionine, which has an assay date of 1-1-2016. S-35 has a half-life of approximately 87 days. What is the activity of the S-35 on 1-31-2016?

$$A = 0.5 \text{ mCi} \cdot e^{-(0.693 \cdot 30 \text{ days} / 87 \text{ days})}; A = 0.5 \text{ mCi} \cdot e^{-0.239}; A = 0.393 \text{ mCi}$$

Radioactive material vendors often include decay tables with their products to assist the user in determining the exact activity remaining in a sample when the original activity and assay dates are known.

Isotope Decay Chart

P-32

Half-life 14.29 days

(Fraction of activity remaining, x days after assay date)

Days	0	1	2	3	4	5	6
0 +	1.000	0.953	0.908	0.865	0.824	0.785	0.747
7	0.712	0.678	0.646	0.616	0.587	0.559	0.532
14	0.507	0.483	0.460	0.438	0.418	0.398	0.379
21	0.361	0.344	0.328	0.312	0.297	0.283	0.270
28	0.257	0.245	0.233	0.222	0.212	0.202	0.192
35	0.183	0.174	0.166	0.158	0.151	0.144	0.137
42	0.130	0.124	0.118	0.113	0.107	0.102	0.097
49	0.093	0.088	0.084	0.080	0.076	0.073	0.069
56	0.066	0.063	0.060	0.057	0.054	0.052	0.049

Example: 100 μCi of P-32 assayed on 1/1/16 is used on 1/17/16. Its activity (16 days elapsed) is $100 \cdot 1 (0.460) = 46 \mu\text{Ci}$.

Another way to consider the remaining activity of a radioactive substance is that after **N** number of half-lives elapsed, the material will have decayed to $1 / 2^N$ of its original value.

<u># of Half-lives elapsed</u>	<u>Fraction Remaining</u>
0	$1 / 2^0 = 1/1$
1	$1 / 2^1 = 1/2$
2	$1 / 2^2 = 1/4$
3	$1 / 2^3 = 1/8$
4	$1 / 2^4 = 1/16$
5	$1 / 2^5 = 1/32$
.....	
10	$1/2^{10} = 1/1024$
N	$1 / 2^N$

ALARA and Principles of Radiation Safety

Experienced radioactive material handlers will already be familiar with the three Basic Safety Principles of radiation safety: **time**, **distance**, and **shielding**. The adept worker will adjust one, two, or a combination of all three of these variables to ensure a safe working environment for themselves and anyone else that may be present in the laboratory. Although we know that some exposure to low levels of radiation may not be harmful, our goal as an institution is to create a workplace where exposures are **As Low As Reasonably Achievable (ALARA)**. ALARA works to minimize radiation exposures to workers, the public and the environment.

The first principle of radiation safety is **time**. By decreasing the amount of time spent near radioactive sources, we can limit unnecessary exposure to others and ourselves. One must also consider exposures to the extremities while handling source material – even if exposure to the whole body is minimal, the dose to the digits or hand can be significant when holding a stock vial for prolonged periods. Return samples or source vials to permanent storage locations after manipulation.

The second principle is **distance**. The inverse square law dictates that the intensity of a field (in this case, energy or radiation) is inversely proportional to the square of the distance from the source (of radiation). Simply put, increasing your distance from a radioactive source decreases your exposure to radiation. In fact, with many radionuclides, the radiation exposure will be zero beyond a certain distance from the source. You may discover that with many of the source materials used in a laboratory setting, manipulations of time and distance will provide sufficient protection from radiation exposure.

The third principle is **shielding**. There will be some instances in which you will have no choice but to spend a significant amount of time handling radioactive material. The limitations of your workspace may also prevent you or your coworkers from increasing the distance from sources of radiation. In these scenarios, you would then implement shielding techniques. The proper shield can be placed between the radioactive source and the space inhabited by you and your co-workers. The shield will absorb the energy being emitted, reducing the amount of radiation dose to humans in the area.

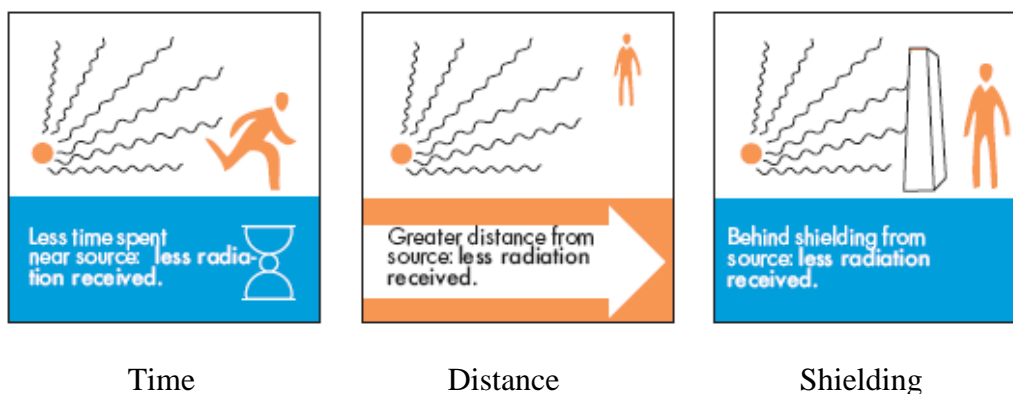


Fig. 7: Radiation Safety Principles

Radioactive Decay and Radiation Emission

Radioactive decay can occur in a variety of ways, in which an unstable nucleus will emit radiation (energy, in the form of subatomic particles or waves). We will limit our discussion to forms of ionizing radiation that a worker at the University of Chicago is likely to encounter. These include **alpha particles**, **beta particles**, and **gamma rays**. In order to work safely with or around these radiation emitters, it is important to have an understanding of their basic physical properties.

Alpha particles consist of two protons and two neutrons; essentially, they constitute a Helium nucleus with a +2 charge. They are very large in comparison with other emitted particles, and highly energetic. Common alpha emitters will be isotopes of heavier metals such as Uranium, Polonium (tobacco smoke), Plutonium, or Americium (smoke detectors).

The strong positive charge of an alpha particle is very hazardous to humans as deposition of the charge into a cell will cause disruption of mitosis or cell death. Fortunately, the particles are too large to effectively penetrate through matter, making them very easy to shield. A piece of notebook paper, clothing, or a layer of dead skin cells will sufficiently shield one from external alpha particle exposure. The threat to humans, therefore, comes from ingestion or inhalation. Once the alpha emitter is inside the body, there is no protection to the linings of the tissues or organs from the alpha particles. In a laboratory setting, the best protection against alpha radiation would be to refrain from eating, drinking, or breathing an alpha emitter.

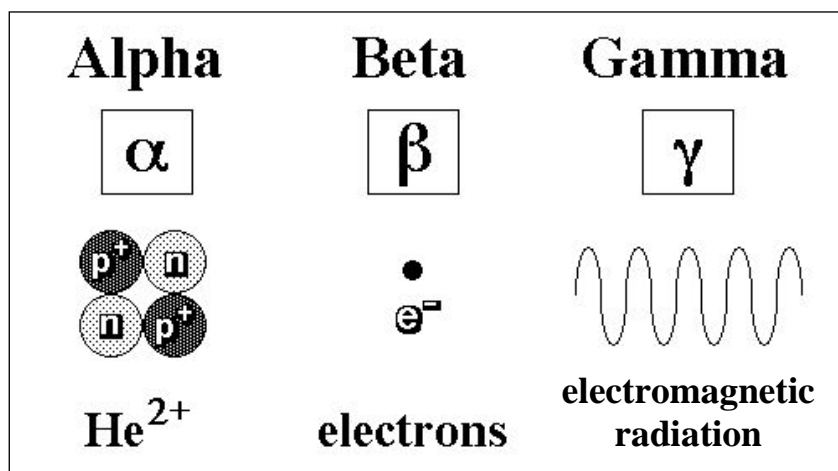


Fig. 8: Types of Ionizing Radiation

A majority of the isotopes used in a laboratory setting will emit **beta particles**. Although there are many methods of beta decay, the most prevalent among the isotopes in use at the University of Chicago is beta negative decay, which involves the emission of electrons from the nucleus. The electrons will have a -1 charge and are relatively small compared to the nucleus. This allows for greater penetrating ability than an alpha particle might exhibit. In fact, the penetrating ability of an individual electron is directly proportional to the amount of energy that electron possesses. The higher the energy, the farther the electron can travel in air (or tissue) while retaining its ionization potential. Because each isotope has a known spectrum of energies for the electrons it emits, we can predict the maximum penetrating distance for the beta particles emitted.

Although not every beta particle emitted by a radioactive isotope will have the maximum energy possible, for safety considerations we consider that *any* beta emitted could travel the maximum distance while retaining ionization potential. Shielding material may be required when occupying distances less than the beta-max (β - max) range in air. Fig. 9 summarizes basic properties of commonly used beta emitters used on campus.

Isotope	H-3	C-14	S-35	P-33	Ca-45	P-32
Half-life	12.4 years	5730 years	87.4 days	25.3 days	162.7 days	14.3 days
Energy β - (max)	18.6 keV	156 keV	167 keV	249 keV	258 keV	1709 keV
β - Range in air	6 mm	24 cm	26 cm	49 cm	50 cm	790 cm

Fig. 9: Basic Properties of Commonly Used β - Emitting Radionuclides

A number of isotopes in laboratory use will emit radiation by production of a **gamma ray**. Unlike alpha and beta, gamma rays are a form of electromagnetic radiation having wavelike properties (no charge or mass). They are also extremely energetic; the combination of these two properties means that gamma rays have the greatest penetrating ability of all. Manipulations of distance are usually insufficient alone in protection from ionizing gamma radiation.

Radiation Shielding in the Laboratory

When working in close proximity to radioactive material, shielding may be utilized to reduce the potential for ionization in human tissue. All beta emitting radionuclides in use at the University of Chicago can be safely shielded using **1 cm thick Plexiglas**. The majority of the electrons do not have sufficient energy to penetrate through the plastic, reducing the exposure on the opposite side. Keep in mind that low-energy beta emitters, such as Carbon-14 (C-14) and Tritium (H-3) have an ionization potential only at very short distances in air. **No shielding is required with H-3 or C-14** as the external exposure from either of these isotopes (at working distances) is likely to be zero.

All gamma emitters, due to their greater penetrating ability, must be shielded with **lead**. The higher density material provides a barrier through which few of the gamma rays can penetrate. Lead is valuable in the laboratory setting due to its malleability – lead foil can be shaped around a gamma-emitting source to adequately shield it in all directions. The half-value layer is a measurement of the thickness of lead required to shield $\frac{1}{2}$ of all gamma rays emitted by a particular isotope. Lead is not commonly used to shield beta emitters due to a phenomenon known as the **Bremsstrahlung effect**. High-density metals such as lead will adequately shield an electron from penetration, but results in the ejection of a subsequent photon, or x-ray. Extremely large amounts of lead, therefore, would be required to shield both the beta and the beta-produced x-ray from the user. This practice is obviously not conducive to efficient or safe work in a laboratory setting, but is often employed in the shipment of small volumes and activities of radioactive material. You may **NOT** use lead to shield waste containers or workspaces in your laboratory when beta-emitters are present!

In order to properly shield oneself from radiation, there is more to do than just selecting the proper material. The integrity of the material must be maintained and monitored regularly, as cracks or gaps may allow fields of radiation to escape. In many cases, the shielding can be directional – for instance, Sulfur-35 (S-35) on a benchtop does not need to be shielded 1 meter in each direction, as a face shield on the benchtop may be sufficient to protect you, while workers in surrounding areas are safe due to the weakly-penetrating beta over a greater distance. Higher energy beta emitters, and gamma emitters, may require shielding in multiple directions, including the adjacent benchtops! Do not forget to shield radioactive waste and source material when exposure rates to adjacent workspaces or aisle ways will be affected.

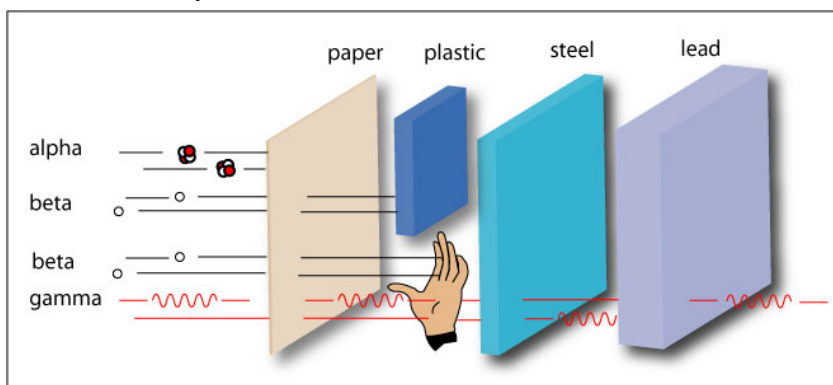


Fig. 10: Shielding Ionizing Radiation

Safety Rules and Regulations

There are multiple sets of guidelines for the safe use of radioactive materials in a laboratory setting at the University of Chicago. A good overview of the practices mandated by the Office of Radiation Safety is identified in the Radiation Safety FAQs, which can be found at the following address:

<https://researchsafety.uchicago.edu/page/radiation-safety-faqs>

Other restrictions prescribed by the Illinois Emergency Management Agency (IEMA), Division of Nuclear Safety are listed here in the Radiation Safety FAQs. All University laboratories are subject to restrictions outlined in the University of Chicago Chemical Hygiene Plan, which overlaps with many facets of radioactive material use.

Although the rules regarding safe use of radioactive material are often straightforward, the interpretations of these rules may vary. If you encounter a situation where it is not entirely clear what is permitted, please contact a representative of the Office of Radiation Safety for clarification.

Research Laboratory

General Rules for the Safe use of Radioactive Material

The following outlines the research laboratory general rules for safe use of radioactive material that the Illinois Emergency Management Agency (IEMA), Division of Nuclear Safety instituted as conditions on the University of Chicago's radioactive material license. Each laboratory is required to comply with these requirements to maintain exposures to radiation to all individuals **As Low As Reasonably Achievable (ALARA)** and to ensure compliance to avoid citations from IEMA for items of non-compliance. In addition, the University of Chicago Radiation Safety Committee along with the Office of Radiation Safety has instituted internal policies and procedures to ensure all exposures to radiation are ALARA. All University of Chicago laboratories (including non-radioactive use areas) are also subject to the guidelines detailed in the University's Chemical Hygiene Plan.

Personal Protective Equipment

Lab coats, disposable gloves, eyewear, etc. are considered personal protective equipment (PPE) and should be worn when working with the radioactive material. Lab coats and gloves should be worn EVERY time when handling radioactive material. Eye protection such as chemical splash goggles should be worn during chemical manipulations. PPE protects your body from possible contamination. Therefore, survey of clothing shall be conducted after every use of radioactive material. Exposed skin, i.e. open-toed shoes, shorts and skirts are not allowed in the laboratories.

Food Handling and Storage

Consumption, storage, and preparation of food and drink are expressly forbidden in University of Chicago laboratories, as well as any areas that are authorized for radioactive material use. For example, the use of microwaves and coffee makers for heating food and/or drink in radioactive material laboratories for human consumption is strictly prohibited! In addition to removing all food from laboratory spaces, any related items (which may indicate evidence of eating or drinking in the lab) must be removed as well. This would include such items as paper cups, water bottles, coffee mugs, and items placed in wastebaskets such as candy wrappers, plastic forks, etc. Be aware that “evidence of eating and drinking in the laboratory” is a violation as severe as actually being caught eating or drinking in a radioactive material area.

Smoking and application of cosmetics (exception being using hand lotions at sink) are also prohibited in the laboratory!

Your lab will often have items being used for experimental purposes, which may be misconstrued as food, drink, or cosmetic applications. Do not store food or drink in any area where unsealed radioactive material is stored or used unless the food or drink is to be used as part of a radioactive material experiment. Common culprits include powdered milk for blots, clear nail polish for microscope slides, bottled waters for plants, etc. Make sure to label these “LAB USE ONLY” to prevent a potential misunderstanding or violation.

The full University of Chicago Chemical Hygiene plan can be found at

<https://researchsafety.uchicago.edu/page/chemical-hygiene>

Occupational Exposure Limits

The United States Nuclear Regulatory Commission (NRC) has established Exposure Limits for all persons classified as Radiation Workers. These are the maximum levels of absorbed dose that a worker may receive in a given year, with the expectation that there is no health risk involved with exposures of this magnitude. At the University of Chicago, these regulations are administered under authority of the Illinois Emergency Management Agency (IEMA), Division of Nuclear Safety.

Most important to remember is the 5 Rem/yr or 5000 mRem/yr dose limit to the whole body.

Exposures to the lens of the eye, and to the organs or extremities, are weighted averages. Therefore, they have higher annual limits (15 Rem/yr and 50 Rem/yr, respectively). A dose of 10 Rem to the lens of the eye, for instance, would not necessarily result in a dose more than 5 Rem to the whole body.

In addition, workers may declare their pregnancy in writing by contacting the Office of Radiation Safety, enabling them to receive additional monitoring and limiting the permitted dose to the embryo or fetus to 0.5 Rem for the duration of the pregnancy.

Minors are permitted only 10% of the annual dose limit for adult workers. Minors are not permitted to use radioactive material at the University of Chicago without prior approval by the Office of Radiation Safety.

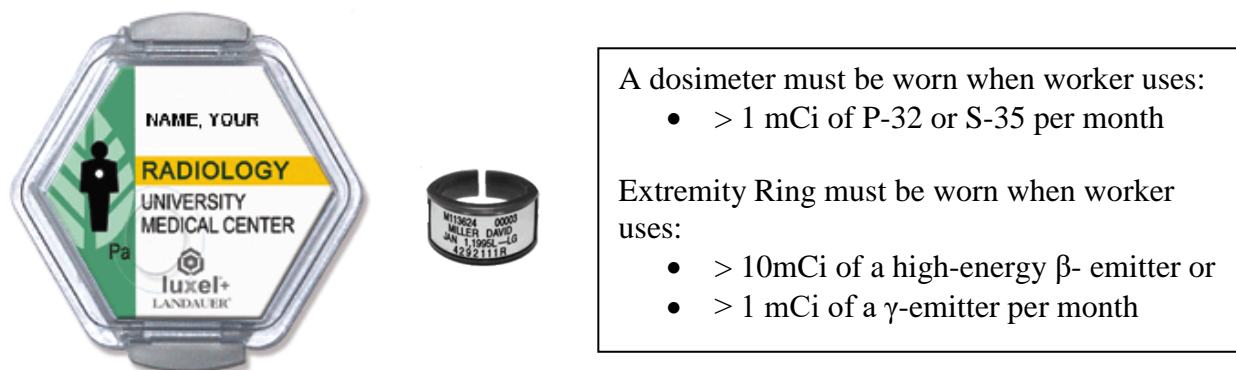
MAXIMUM PERMISSIBLE DOSE LIMITS FOR RADIATION WORKERS	ADULT WORKERS	<18 YEARS OLD
Whole Body (Total Effective Dose Equivalent) Sum of Internal & External Exposure	5 Rem/Year	0.5 Rem/Year
Any Individual Organ or Tissue Other than lens of Eye (Total Organ Dose Equivalent) Sum of Internal & External Exposure	50 Rem/Year	5 Rem/Year
Lens of the Eye	15 Rem/Year	1.5 Rem/Year
Skin of Whole Body	50 Rem/Year	5 Rem/Year
Extremities	50 Rem/Year	5 Rem/Year
Fetus* (term) 0.5 Rem		

Table 1: Annual Dose Limits for Radiation Workers

Dosimetry

One method by which the Office of Radiation Safety monitors radiation exposure to its radioactive material workers is by issuing dosimetry badges (dosimeters). The dosimeter is to be worn on the portion of the body where the highest exposure is likely to be received such as on the lapel. The dosimeter must be worn whenever the worker is in an area of radioactive material use or storage.

All persons whose work is associated with radiation that could result in exposure above 10% of the annual limits (500mRem) must wear radiation dosimeters. Whole body dosimeters and extremity rings are issued for a one to two-month wear cycle and are used to monitor exposure from high-energy beta, neutron, and gamma-ray sources. Workers who use any quantities of H-3 or C-14, or use less than 1 mCi a month of S-35 and/or P-32 are not required to wear a dosimeter. Workers that use 10 mCi or more of P-32 (or other high-energy beta emitters) at a time, or use more than 1 mCi of a gamma-ray source per month, are required to wear a whole-body dosimeter and an extremity ring.



A dosimeter must be worn when worker uses:

- > 1 mCi of P-32 or S-35 per month

Extremity Ring must be worn when worker uses:

- > 10mCi of a high-energy β - emitter or
- > 1 mCi of a γ -emitter per month

Fig. 11: Whole Body Dosimeter and Extremity Ring

Wear whole body dosimeters at all time while in areas where radioactive material is used or stored. These monitoring devices must be worn on the part of the body where the highest exposure is expected. When required to wear an extremity ring, the label must be turned inward towards material.

Requests for starting and canceling radiation dosimeter service must be made by completing a green request card, available from the Office of Radiation Safety. Since dosimeters have to be ordered and/or discontinued by the Office of Radiation Safety several weeks in advance, request cards should be received in M031A no later than the dates specified by the Office of Radiation Safety for the change to become effective for the next wear period.

Dosimetry records are maintained by the Office of Radiation Safety. Wearers are encouraged to request their radiation exposure readings. Written requests for exposure information should be directed to the Office of Radiation Safety. Annual reports are submitted to departments for distribution to monitored individuals within the department.

Dosimeters are to be returned to the distribution stations by the 10th of the month.

Radiation Dosimeter Distribution and Pick-up

Radiation dosimeters shall be returned to the distribution station by the 10th of the month of the next wear period. The wear periods are noted below along with the dosimeter distribution date for the new wear period and deadline to return dosimeters from the previous wear period.

Please note that “late fee” charges will be assessed for delinquent or late dosimeter returns.

BIMONTHLY DISTRIBUTION DATE OF DOSIMETERS FOR NEW WEAR PERIOD	BIMONTHLY WEAR PERIOD DATE	BIMONTHLY DEADLINE TO RETURN PREVIOUS DOSIMETERS
October 31	Nov. 1 to Dec. 31	January 10
December 31	Jan. 1 to Feb. 28	March 10
February 28	Mar. 1 to Apr 30	May 10
April 30	May 1 to Jun. 30	July 10
June 30	Jul. 1 to Aug. 31	September 10
August 31	Sept. 1 to Oct. 31	November 10
October 31	Nov. 1 to Dec. 31	January 10

Table 2: Radiation Dosimeter Distribution and Pickup Schedule

Individual Radiation Exposure Investigational Limits

The University of Chicago's Radiation Safety Officer reviews exposure reports and evaluates individual exposures that exceed the following investigational limits, calculated bi-monthly for research laboratory radioactive material users:

QUARTERLY INVESTIGATIONAL LIMIT FOR MONTHLY WEAR DATES

	LEVEL I	LEVEL II
Total Effective Dose Equivalent (TEDE) [Exposure to the Whole Body]	>125 mRem	>312 mRem
Eye Dose Equivalent (EDE) [Exposure to the Lens of the Eye]	>375 mRem	>938 mRem
Shallow Dose Equivalent (SDE) [Exposure to the Skin or any Extremity]	>1250 mRem	>3125 mRem

BIMONTHLY INVESTIGATIONAL LIMIT FOR BIMONTHLY WEAR DATES

	LEVEL I	LEVEL II
Total Effective Dose Equivalent (TEDE) [Exposure to the Whole Body]	>83 mRem	>208 mRem
Eye Dose Equivalent (EDE) [Exposure to the Lens of the Eye]	>250 mRem	>625 mRem
Shallow Dose Equivalent (SDE) [Exposure to the Skin or any Extremity]	>833 mRem	>2080 mRem

Personnel whose dose exceeds the Level I limit will be notified by the Radiation Safety Officer, with results presented to the University of Chicago Radiation Safety Committee. Exposure reports in excess of Level II limits will initiate further investigation and evaluation of radiation safety practices.

For more information, please refer to the Radiation Safety policy at Rad Safety FAQs regarding occupational exposure monitoring, located on the Office of Research Safety website at

<https://researchsafety.uchicago.edu/page/radiation-safety-faqs>

Security

It is the responsibility of each PI to maintain sources of radiation, (including radioactive material samples and radioactive waste) under constant surveillance and control at all times. Therefore, as approved radiation workers, you are also responsible for the security of radioactive material in your PI's laboratory spaces.

Some techniques you should employ to provide proper security:

- Rooms where radioactive material is used or stored must be locked when unattended.
- Eliminate unnecessary quantities of radioactive materials.
- Maintain safe and secure storage of all radioactive material located in your space.
- Keep an eye out for unexpected visitors, make inquiries, and have a plan to deal with those situations. Visitors must adhere to all radiation safety guidelines as well!
- Report to University Police (123 or 2-8181) or Public Safety (2-6262) any individuals whose behavior you find threatening or suspicious.

It is also the responsibility of each PI to promptly report loss, theft, or damage to any source of radioactive material (radioactive waste, stock solution vials, sealed sources, etc.) to the Office of Radiation Safety.

Radioactive Material Labels

In order to alert others in your workspace to the potential hazards involved, all radioactive material workspaces must be clearly identified (with a posting or label) and protected by absorbent coverings. Make sure that the work area is clearly defined – a border created with “radioactive material” tape is most effective – and that individual items which are used in the experiment are labeled with a radioactive trefoil symbol as well.

Sources or samples labeled with radioactive material must be labeled with a radioactive trefoil, isotope, estimate of activity, and date. This includes stock vials, stored radioactive samples, and all radioactive waste containers.

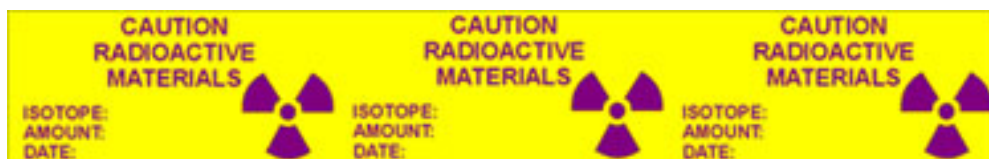


Fig. 12: “Caution Radioactive Materials” Label

Be aware that the “Caution Radioactive Materials” posting on your laboratory doors does NOT serve as adequate posting of your workspace. This posting indicates that the room is approved for radioactive material work. Each individual workspace, whether it is a permanent area for running radioactive gels or a temporary space on your own bench, must be thoroughly labeled at the time

of use. It must be made abundantly clear to any outside observer who may venture into your laboratory that radioactive materials may be present in the workspace.

Transport/Transfer of Radioactive Materials

As a radiation worker at the University of Chicago, you may be required to transport radioactive materials from one approved room to another. This may involve walking across the hallway or across campus, forcing you to travel through areas that are not approved for radioactive material use. In order to do this safely and accurately, the following guidelines must be followed:

- Transport all radioactive materials in sealed, spill-proof containers.
- Shield the radioactive material (if necessary) minimizing radiation exposure to the general public.
- Maintain possession of radioactive materials at all times. Walk directly to your destination - no stopping for lunch or other errands in the course of your travels!

Radioactive materials of any kind may not be transported by motor vehicle or removed from the University of Chicago campus. All radioactive materials, no matter how small the volume or activity, are subject to Department of Transportation guidelines for proper shipping. In addition to penalties for the institution and the PI, a **person who knowingly violates a requirement of the Federal hazardous material transportation law is liable for a civil penalty of up to \$27,500 or imprisoned up to five years!**

Please contact the Office of Radiation Safety to facilitate transfer of radioactive materials to or from another institution.

Transfers of radioactive material from one PI to another are permissible but require pre-approval by the Radiation Safety Officer.

On the occasion that a package containing radioactive material is delivered directly to your laboratory, please call the Office of Radiation Safety immediately. **All radioactive material entering or leaving the University of Chicago must be processed by the Office of Radiation Safety.**

Radioactive Material Procurement

The purchase of radioactive materials including both licensed and license-exempt quantities is handled through the Office of Radiation Safety. Only PIs with an approved protocol will be allowed to order radioactive materials. The ordering will be limited to the isotopes, chemical forms, and maximum activity per month as listed in the protocol application.

Radioactive material must be ordered by a representative of your laboratory through the BuySite ordering system. Only trained, authorized BuySite users may enter the order online. An Account Administrator (AA) for your department will review your request and approve the release of funds. The Office of Radiation Safety will also review the order and approve if the laboratory is authorized for the material. Orders received before 12:00pm by the Office of Radiation Safety will be processed the same day.

Radioactive Material Procurement - Ordering Process

Only radioactive material items may be included on a radioactive material order. If non-radioactive material items are on a radioactive material order, the order will be rejected by Office of Radiation Safety. Anyone found not following the proper ordering procedures risk having his or her ordering privileges denied and suspension of the protocol.

Radioactive material orders must be placed through the University of Chicago's BuySite procurement system.

Researchers are only allowed to order radioactive material listed on their approved radioactive material protocol. If you need a copy of the protocol application, please call the Office of Radiation Safety at 2-6299.

When placing a radioactive material order you **MUST** check the "Radioisotope Order" box.

When entering a radioactive material order indicate the following on the order:

The shipping address must be:

Receiving Dock
The University of Chicago
Office of Radiation Safety
5835 South Cottage Grove Avenue
Chicago, Illinois 60637

The billing address must be:

Central Procurement Services
6054 S. Drexel Avenue
Suite 400
Chicago, Illinois 60637

Your Profile (Buyer Info): Along with your name, include the PI name and HP10 # (e.g. James Marsicek/Dr. John Doe, HP10# 3937). This information (PI and protocol number – HP10#) will assist Office of Radiation Safety staff to approve your orders more quickly.

Product Information: Indicate the isotope, catalog number, product description, number of units, and activity (mCi or μ Ci). **If requesting a product from the Fresh Lot, please specify in the “Note to the Supplier” section.**

Workflow: After creating your order and submitting it, it will be sent to the AA for approval. Once approved by the AA the order will be sent to the Office of Radiation Safety. The Office of Radiation Safety approvers will review the order, compare the order to the approved protocol and if approved, will place the order from the vendor.

The Office of Radiation Safety contacts the radioactive material vendor to purchase the item you requested. Your lab will receive verification of this order, along with a phone call on the day the item has been received. Generally, radioactive items reach the University of Chicago at 11am Monday-Friday, are processed and available for pickup between 1-2pm. Check with your lab mates or call Radiation Safety if you have not received verification on the expected date. Adverse weather, holidays, and product availability can affect the delivery date.

Any authorized Radioactive Material User may pick-up packages for their laboratory from the Office of Radiation Safety. Bring your identification card as you will have to sign for the receipt of any radioactive materials. You will also receive a ‘Receipt and Disposal Record’ for tracking the use and disposal of this material. Return directly to your laboratory with the original packaging and ‘Receipt Disposal Record’.

If you will not use the material immediately, the source vial or kit must be stored in the appropriate refrigerator, freezer, or incubator labeled for RAM. Wearing the proper PPE, remove the vial from the outer packaging. **Write the receipt date and inventory number on a sticker or the vial itself.** Your PI’s name should also be written on the vial if you share a freezer or refrigerator with other labs. Survey the outer packaging to verify that it is contamination free, deface or remove all “radioactive material” labeling, and dispose as regular trash if no contamination is identified.

The ‘Receipt and Disposal Records’ must be stored in an accessible location. Your laboratory designee should have a folder or three-ring binder prepared for this purpose. Inform the laboratory designee and the intended recipient of the radioactive material that the item has arrived and has been placed in storage.

Authority and Responsibility

Office of Radiation Safety is responsible for:

1. Reviewing and approving the radioactive material orders submitted through the BuySite procurement system in a timely manner.
2. Ensure all radioactive material orders meet the requirements of the PI's protocol.
3. Ensure all radioactive material orders meet the requirements of the University of Chicago radioactive material license.

PI is responsible for:

1. Having an approved protocol* for the possession and use of radioactive materials.
2. Submitting an amendment application for radioactive material they would like to order that are not listed on their protocol (e.g. isotope, chemical form, over monthly order limit).
3. Ensuring the appropriate account numbers are used and entered into the BuySite procurement system for vendor payment.
4. Ensure individuals under his or her supervision do not order unnecessary amounts of radioactive material.

Employees/Laboratory Staff is responsible for:

1. Only ordering radioactive materials that are approved in the protocol and ordering within the order limits.
2. Ensuring proper information (e.g. shipping address, billing address, catalog, activity, etc.) outlined in this procedure is entered for radioactive material orders.
3. Ensuring that the "Radioisotope Order" button is checked for each radioactive material order placed through the BuySite procurement system.
4. Ensure only radioactive material items are included with radioactive material orders.

*The definition of an approved protocol is one that is approved by the University Of Chicago Radiation Safety Committee that has no outstanding violations that would warrant a suspension.

Radionuclide Receipt and Usage

The Office of Radiation Safety will issue a radioactive material package a ‘**Receipt and Disposal Record**’ with each radioactive material order placed by the PI. The record incorporates receipt, usage and disposal information for radioactive material. This documentation process is what is called the “Cradle-To-Grave” concept for tracking radioactive material from the time the material is received on campus to the time of its disposal. It creates an effective paper trail to document where your radioactive material was stored or disposed at any time.

Receipt and Disposal Record Instructions

- The record is issued by the Office of Radiation Safety and delivered to the end user with the radioactive stock in room W01.
- For identification purposes, **record the receipt date and inventory number** (using a permanent marker) on the outside of your stock vial.
- Notify your Laboratory Designee whenever a new item arrives!
- Records must be accessible to all users and inspectors at all times. The logs should be kept in a three-ring binder or a folder near the radioactive material storage area (refrigerator, freezer, etc.)
- Radioactive material users **must** record the proper usage and disposal information on the ‘Receipt and Disposal Record’ immediately after each use.
- The following information must be recorded:
 - Date of use
 - Activity (or volume) removed
 - Approximation of waste generated (fraction of 100%)
 - User’s initials
 - Waste manifest numbers of containers to which radioactive waste was disposed (must be listed on the bottom portion of the usage log immediately after the generation and disposal of radioactive waste).

When the contents of the stock vial are exhausted or no further aliquots will be made, the vial can be properly disposed to a stock vial disposal box. Lab personnel **must** enter **both** the “remaining activity” and the “stock vial disposal box manifest number” on the record.

A copy of the completed ‘Receipt and Disposal Record’ **must** be submitted to the Office of Radiation Safety. Items listed on the radioactive material inventory will not be deleted until the properly completed records are submitted. Records with incomplete or missing information will not be removed from your PI’s radioactive material inventory.

Fig. 13 is an example of a ‘Receipt and Disposal Record’. In this example, information that the user will record on the form is listed inside a circle. Instructions for completing the form are indicated in *italics*. The Office of Radiation Safety recommends that each user complete the necessary information in dark, indelible ink. Any corrections to an entry on the record, or any other official Radiation Safety document, should be done by striking out the incorrect information with

a horizontal black line. Write the correct information alongside the previous entry, along with your initials signifying the change.

~~—100 ml—~~ 150 ml DS

Fractions of waste material generated for each type of waste container (zero to 100%) may be estimated. It is understood that you may not be able to determine the exact activity of radioactive waste that ends up in each end product. In these cases, make a conservative estimate as to the MAXIMUM amount of activity that may be present in the waste when recording the value on the waste manifest log and the corresponding fraction on the 'Receipt and Disposal Record'.

Example: Source vial contains 0.25 mCi in a volume of 250 microliters, which equates to a concentration of 1 mCi / ml. If a volume of 100 microliters (0.1 ml) is removed from the vial, the total activity of the waste generated cannot exceed

$$0.1 \text{ ml} \times 1.0 \text{ mCi / ml} = 0.1 \text{ mCi}$$

The user "YOU" estimated that 90% of the waste generated was of the "Dry Solid" variety and the other 10% was incorporated into "Aqueous" waste. Although we cannot really quantify how much of the original activity removed went to waste, we know that it cannot be more than the 0.1 mCi removed from the stock vial. A conservative estimate of activity placed into the waste would be

$$90\% \text{ of } 0.1 \text{ mCi} = 0.09 \text{ mCi Dry Solid}$$

$$10\% \text{ of } 0.1 \text{ mCi} = 0.01 \text{ mCi Aqueous}$$

These values can now be recorded on the Waste Manifest Form of the corresponding radioactive waste containers (see "Waste Handling", page 44).

University of Chicago
Environmental Health and Safety
Radiation Safety Division
RADIOACTIVE MATERIAL PACKAGE RECEIPT AND DISPOSAL RECORD

Principal Investigator: OBAMA, BARACK	Inventory #: 081104001	Permit #: R-2008
Lot Number:	P.O. Number:	
Receipt Date: 11/04/2008 <i>record on stock vial</i>	Radionuclide: P-32	
Lab Contact: EMANUEL, RAHM	Compound: alpha-dCTP	
Contact Phone: (202)456-1414	Number of Vials: 1	
Vendor: USA RADIONUCLIDES	Total Activity (mCi): 0.250	

Vial Disposal Record

Percent Activity Placed in Waste

Used By	Date	Activity Removed (mCi)	% Dry Storage Drum	% Aqueous Container	% Aqueous Drain Disposal	% Scint. Vial Drum	% Animal Waste	Other (explain)
JMMC	11-05-08	0.250	53	47				

Enter activity remaining in the vial (mCi)	0	<i>Required for disposal!</i>
Enter the stock vial disposal box manifest number	S - 60637	

When the content of the stock vial are exhausted or no further aliquots will be removed from the vial, enter the residual or remaining activity on the stock vial manifest and place the vial into the corresponding stock vial disposal box.

Record disposal container manifest numbers used in each waste transfer of this material:

Dry Solid		Aqueous	
1. D-1971	3.	1. A-1973	3.
2.	4.	2.	4.

Record waste manifest numbers of all waste containers that were used!!!

Printed: 02/05/09

RMA-39 (6/23/03)

Fig. 13: Receipt and Disposal Record Example

Waste Handling

When your experiment is complete or you no longer need the source material, survey your gloves once again and return the vial to its storage location. All temporary waste containers should be consolidated and removed to the permanent radioactive manifested waste containers. Absorbent paper, pads, and any potentially contaminated disposable items should be placed in the manifested waste containers as well. Today's date and estimate of the (maximum) activity in the waste must be recorded on the 'Waste Manifest Log'.

Because a portion of the radioactive material taken from the source vial may have been collected as waste, we must "track" its migration by entering a new storage location on the 'Receipt and Disposal Record' (see Fig. 13). The columns on the right indicate various mediums to which radioactive material may have been transferred. Record a percentage of the radioactive waste that you generated for any of these mediums. For instance, if your experiment produced radioactive dry solid waste and trace amounts of aqueous waste to the sink, you could indicate "53%" in the dry storage drum column and "47%" in the aqueous drain disposal column. If only aqueous waste was generated and transferred to a manifested container, you would record 100% in the aqueous container column. Now record the five-digit waste manifest number (found in the upper right-hand corner of the yellow 'Waste Manifest', (Fig. 14) at the bottom of the 'Receipt and Disposal Record' (Fig. 13). You now have a paper trail indicating when and where the radioactive material was stored.

The last step in any procedure involving radioactive material handling is a contamination survey. (Follow the guidelines for post-experiment survey, found on page 44). You are responsible for surveying your workspace immediately after completing your procedure. Include all items you may have touched, as well as the floors in the areas you transported radioactive material. Do not forget to survey your hands, shoes, lab coat, chair, etc. Follow the decontamination guidelines (page 47) if you find any elevated survey readings. If all areas surveyed are less than or equal to background (Geiger-Mueller (GM) detector, approximately 0.03 mR/hr), your survey (and your radioactive material procedure) is complete.

Radioactive Waste Management

All radioactive waste generated at the University of Chicago must be disposed via a manifested waste container or approved radioactive waste disposal sink. The University of Chicago DOES NOT permit the long-term storage or “decay-in-storage” of radioactive waste in a laboratory setting.

Each manifested waste container bears a color-coded instruction label, which explains proper disposal techniques and a description of permissible waste items. If your laboratory does not have an appropriate container for the type of waste you are generating, call the Office of Radiation Safety to have a special container delivered.

Manifested waste containers are collected by the Office of Radiation Safety staff twice weekly (Tuesdays and Fridays). To request a waste pick up, you must identify the PI, room number, manifest number, isotope, and container type for collection. You must call in these requests to the Radiation Safety Office at (773)702-6299 and may leave a message on the voicemail.

The following is an outline of the approved waste disposal methods. Please refer to Appendix B of this booklet for the complete list of instruction labels you may find on a waste container.

Dry Solid waste refers to any non-liquid substance which has been (or may have been) contaminated with radioactive material. This includes paper, plastics, disposable gloves, cell samples that have been lysed, etc. Small volumes of liquids MAY be added to the Dry Solid Waste if they can be completely absorbed by the contents of the container. Five milliliters of a liquid soaked into a paper towel is permissible. Five milliliters of liquid inside a tube or culture flask, however, is not permissible. Biohazardous, toxic, flammable, and organic wastes are PROHIBITED unless otherwise specified.

Dry Solid Waste is generally collected in a 10-gallon plastic bag and stored in the lab inside a Fiberboard Drum (container type: FIB) or 10-gallon steel drum (container type: D10). Please note that only ONE ISOTOPE PER CONTAINER is permitted (no mixing of isotopes unless your protocol requires it).

Dry Solid Waste containers may be divided into the following categories:

Short Lived Isotopes – Dry Solid Waste which has a half-life of less than 90 days (P-32, P-33, S-35, Cr-51, or I-125).

Long Lived Isotopes – Dry Solid Waste that has a half-life of greater than 90 days (H-3, C-14, Na-22, etc.). Long -Lived Isotopes are collected in either Incinerable or Compactable containers.

Incinerable – Dry Solid Waste containing only papers, plastics, or gloves. Metals (including foils and sharps) and glass are prohibited.

Compactible – Dry Solid Waste consisting primarily of glass or metals.

Aqueous Waste may be disposed by one of two methods:

Manifested Carboy – These are large plastic containers for the collection of aqueous waste ONLY. Waste must be free of pipette tips, biohazardous material, organic substances, or solids of any kind. Solutions must have a pH value between 4 and 10. Carboys are available in 6-liter (CRB) and 25-liter (C25) capacities. The Office of Radiation Safety recommends collecting all “first wash” gel buffer from electrophoresis involving radioactive substances in a liquid carboy.

Drain (Sink) Disposal – Low levels of radioactive waste in readily dispersible, non-hazardous aqueous form MAY be disposed by discharging them in an approved Radioactive Waste Disposal Sink, bearing a label issued by the Office of Radiation Safety. In addition to limitations based on pH and biohazards, each sink has a daily limit on activities that can be disposed:

One microcurie (1 μ Ci) per day of any radioisotope having a half-life greater than thirty (30) days. This includes **H-3, C-14, S-35, I-125**, and others.

Ten microcuries (10 μ Ci) per day of any radioisotope having a half-life less than thirty (30) days. **P-32, P-33, and Cr-51** are most commonly used.

All radioactive drain disposal must be recorded on Aqueous Waste Drain Disposal Record by lab personnel (Fig. 15). The record must list the date, isotope, volume, activity and the initials of the individual conducting the disposal. In addition, the Office of Radiation Safety will require labs to submit their drain disposal records each quarter.

Stock Vial Disposal

All source vials (stock vials and RIA kits, regardless of remaining activity) must be placed into Manifested Stock Vial Boxes at the time of disposal. Source vials may not be disposed into the Dry Solid Waste containers, as the vials must be accessible until the time they are removed from your laboratory by the Office of Radiation Safety. This allows an additional tracking location for the source material (also known as “the grave” in the Cradle-to-Grave tracking system). Record the remaining activity in the vial, along with today’s date, on the Stock Vial Box waste manifest. Now record the 5-digit Waste Manifest Number on the corresponding ‘Receipt and Disposal Record’ (Fig. 13). This item can now be removed from the Radioactive Material inventory by faxing a copy of the ‘Receipt and Disposal Record’ to the Office of Radiation Safety. Always notify your Laboratory Designee when disposing of a stock vial or RIA kit.

The University of Chicago Radioactive Aqueous Waste Drain Disposal Record
--

Principal Investigator (PI): _____ Lab Location: _____

Period **1/1/20 to 3/31/20** ☐ Lab Conducted No Drain Disposal

Record all aqueous waste disposal procedures conducted in your laboratory. Enter each date of disposal, isotope(s) contained in the waste, volume to be disposed, activity of waste, and the initials of the person conducting the disposal procedure.

Daily Sanitary Sewer Disposal Limits:

- One microcurie (1 μCi) per day of any radioisotope having a half-life greater than thirty (30) days.
(Example: H-3, C-14, S-35, Ca-45, Na-22, Cl-36, etc.)
- Ten microcuries (10 μCi) per day of any radioisotope having a half-life less than thirty (30) days.
(Example: P-32, P-33, Cr-51, etc.)

Date	Radionuclide(s)	Volume (ml)	Activity (μCi)	Initials

Fig. 15: Radioactive Aqueous Waste Drain Disposal Record

Liquid Scintillation Vial Disposal

The University of Chicago recommends the use of biodegradable scintillation cocktail when using Liquid Scintillation Counter (LSC). Be aware that although these cocktails may be non-toxic and non-radioactive, or “deregulated”, they must be disposed as chemical hazardous waste and cannot be disposed via the sanitary sewer. Collect all deregulated scintillation vials in a solid, leak proof container, such as a plastic bucket or large metal canister for waste collection. Laboratories within the medical complex are to contact the Hospital Safety Office (2-1733) for disposal details. Laboratories outside the medical center are to contact the University of Chicago Safety Office (2-9999) for disposal details.

Liquid scintillation vials containing activities of **0.05 $\mu\text{Ci/ml}$ or less of H-3, C-14, or I-125** may be disposed of as chemical hazardous waste and are not considered radioactive (regulated). All other scintillation vials containing radioactive material must be collected for disposal by the Office of Radiation Safety. Your laboratory will be issued a manifested waste container for the collection of tightly sealed scintillation vials.

For short-lived isotopes such as P-32, P-33, S-35, Cr-51, etc., scintillation vials with counts greater than 100 cpm must be packaged into the appropriate scintillation vial drum.

The concentration can be estimated as follows:

$$\text{Counts in Vial} / (2.2 \times 10^6) \times \text{volume (ml)} \times \text{Efficiency of LSC}$$

Default efficiency value for most LSC is approximately 50%

Some common examples of cpm limits for scintillation vial disposal are given in the table below for the long-lived and short-lived radioactive isotopes respectively:

Isotope	Volume	Efficiency	Maximum Disposal Limit (cpm)	Resulting Activity ($\mu\text{Ci/ml}$)
H-3/C-14/I-125	1ml	50%	51500	0.047
H-3/C-14/I-125	5ml	50%	275000	0.05
H-3/C-14/I-125	10ml	50%	550000	0.05

Isotope	Maximum Disposal Limit (cpm)
Short-Lived Isotopes	100

Table 3: Common Examples of CPM Limits for Scintillation Vial Disposal

Survey Instruments

There are several types of portable radiation survey instruments in use on campus. As a user of radioactive materials, you are expected to be able to properly use all the survey meters in your laboratory. Depending upon the isotopes being used, the survey instrument will be utilized to assess exposure rates due to known quantities of radioactive material, identification of items or areas contaminated with radioactive material, or both. The Office of Radiation Safety performs an annual calibration and quarterly operational checks of all survey instruments to ensure they are in proper working condition.

Required Radiation Detection Instruments

PIs must provide radiation survey meters or appropriate counting instruments for use in laboratories where radioactive materials are used.

Low-energy beta emitters (H-3) require a liquid scintillation counter (LSC) for wipe test surveys.

Intermediate/high-energy beta and high-energy gamma emitters (C-14, Na-22, P-32, P-33, S-35, Cl-36, Ca-45, Cr-51, Zn-65, Rb-86, Nb-95, Tc-99m, I-123) require a survey meter with a thin-end window or pancake probe, such as a Geiger-Mueller (GM) detector.

Low-energy gamma emitters (I-125) require a survey meter with a sodium iodide (NaI) crystal scintillation detector.

Geiger-Mueller Detector

The Geiger-Mueller (GM) counter (also referred to as a detector or survey meter) is the most common radiation detection instrument on campus. An ionization in the detector results in a large output pulse that causes a needle deflection and an audio response. All ionizing events create the same size output pulse, so the meter does not distinguish the types and energies of radiation.

Most laboratories on campus use the Ludlum Model 3 GM detectors. This model of GM detector has two types of probe: end-window probe and pancake probe. Beta particles must have sufficient kinetic energy to pass through the detector window and into the gas-filled, sensitive volume of the detector. Very low energy beta emitters such as H-3 are not detectable since their betas do not have enough energy to penetrate through the detector window (a thin film such as Mylar). Most beta particles emitted from C-14 and S-35 have enough kinetic energy to pass through the window. Covering the window with a cap or plastic wrap will shield most or all of their betas from entering

the detector, rendering it ineffective for radiation detection. Protecting the probe with plastic or Parafilm is only advisable when using a high-energy beta emitter such as P-32.

Detector Efficiency

A survey meter's ability to detect radiation can be expressed as the detector's efficiency. The efficiency of a meter for a specific source of radiation is given by the ratio of the meter count rate to the actual disintegration rate of the radiation source.

$$\text{Detector Efficiency} = \text{Meter Reading} / \text{Actual Disintegration Rate}$$

Some examples of approximate GM detector efficiencies through end-window or pancake probe are given below:

RADIONUCLIDE	PANCAKE EFFICIENCY	END WINDOW EFFICIENCY
H-3	Not Detectable	Not Detectable
C-14	3%	1.5 to 2%
S-35	4-5%	2 to 2.5%
P-32	28 to 30%	14-15%

Table 4: GM Probe Efficiencies

Detection efficiency varies greatly, depending upon the isotope that is emitting the radiation.

Survey Instrument Calibration

The Office of Radiation Safety will calibrate survey meters, check for proper operation and replace weak or defective batteries at least annually. If needed, Office of Radiation Safety will send the survey instrument to the manufacturer for calibration. The Office of Radiation Safety must be notified when a new instrument is to be purchased. The Office of Radiation Safety will affix a sealed source to the new instrument (if a source was not purchased with the instrument) to be used for the instrument operational checks. A copy of the manufacturer's calibration certificate must be submitted to the Office of Radiation Safety.

Most survey meters have scales that read in milli Roentgen per hour (mR/hr), counts per minute (cpm), or counts per second (cps). The cpm or cps scales indicate the rate of incident radiation (number of photons or particles detected over unit time). The mR/hr scales indicate the rate of radiation exposure, which is an estimate of the radiation dose to human tissue over unit time.

Two general types of calibration procedures:

- 1) Meters with unit cpm or cps: These meters are calibrated using a pulse generator so that the cpm or cps scales read correctly (i.e. one pulse in = one survey meter count). If the meter reads only in cpm or cps, an additional calibration sticker will be placed on the instrument giving the mR/hr equivalent of the count rate reading.
- 2) Meters with unit mR/hr: Survey meters that are used for radiation exposure measurements are calibrated in a radiation field of known quantity.

Survey Instrument Repairs

It is the PI's responsibility to have the meters available for use and to keep the meters operational. The Office of Radiation Safety can provide assistance in maintaining or servicing existing meters.

Minor repairs of malfunctioning survey instruments can be made by the Office of Radiation Safety for many instruments in wide use. Instruments requiring major repairs or instruments for which the Office of Radiation Safety does not maintain parts will be returned to the manufacturer for repair and recalibration.

Preparing to Use a Geiger-Mueller Survey Meter

Survey Meter Battery Test

A battery check **must** be performed each day that the instrument is used, at a minimum. However, we recommend the battery test be completed each time the meter is turned on. If the battery test falls below the battery condition line, the instrument must be taken out of use until the batteries are replaced.

Procedure for completing the battery test:

- 1) Move switch on meter base to “BAT” position.



- 2) The indicator needle must deflect to the “BAT TEST” range.

PASS!



- 3) If it does not pass, you may not use the instrument! Change the batteries and check the battery response again or call the Office of Radiation Safety for assistance.

FAIL!



Survey Meter Operational Check

An instrument operational check must be performed with a dedicated check source each day an instrument is used. The reading taken must fall within the range limits stated on the side of the instrument. If the reading falls outside the stated range, the instrument may not be used and must be taken out of service. Contact the Office of Radiation Safety for a temporary replacement meter and service inquiry.

Procedure for Completing the Operational Check

- 1) With the meter turned on, hold the probe flush against the check source location (black X or trefoil label) on the side of the meter. The red cap (if present) should be removed from all GM probes.

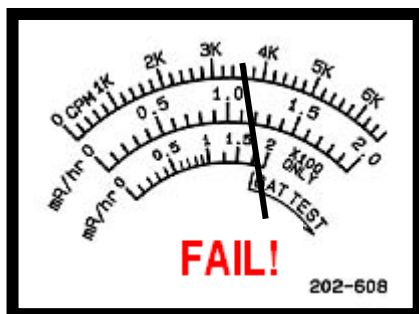


- 2) The display must read within the range limits on the “Check source Measurement” sticker.



Check source Measurement	
Date	GM <u>0.4 – 0.6</u> mR/hr
<u>3 / 31 / 16</u>	NaI _____ cpm

- 3) Contact Office of Radiation Safety if the reading falls outside the range. Do not use this instrument!



Reading the Survey Meter Dial

Survey meters usually have either of the following scales: cpm, cps, mR/hr, mR/hr x100 only or combination of those. First, determine the proper unit of measurement (mR/hr, cpm, or cps) for your survey meter. Observe the highest deflection of the needle on the meter face. If the needle deflects all the way to the right, you must move the indicator switch to a higher multiplier scale. The correct reading is the meter reading times the value on the multiplier scale (x0.1, x1, x10 or x100).

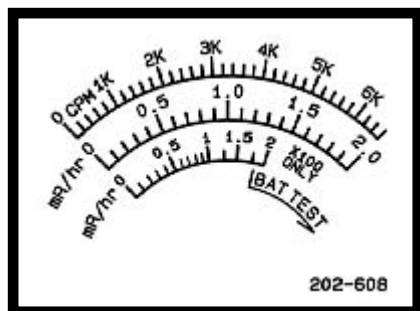


Fig. 16: Survey Meter Display

For example, if the unit of measurement were “mR/hr”, the correct exposure rate indicated below would be $1.1 \times 0.1 = 0.11$ mR/hr.

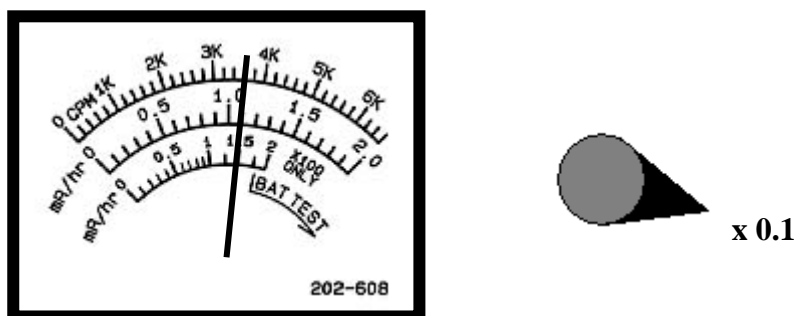


Fig. 17: Survey Meter Example

Very high radiation fields or electrical interference may temporarily overload the detector circuit, resulting in a partial or complete loss of meter or audio response. If this happens, remove the meter and yourself from the area and push the reset button or turn the meter off and on. The meter should resume normal operation at this time.

Effective Use of a Survey Meter

Geiger-Mueller (GM) Detector Survey

After performing the battery check and operational check, set the dial switch to the lowest scale. The lowest scale on a Ludlum Model 3 is the “x0.1” dial setting.

Measure the Instrument Background by pointing the probe towards an area free from radioactive materials. **“Instrument Background” is the highest reading when no radioactive material is present.**

Average Backgrounds (end window or pancake probe)

~ 0.03 mR/hr
30 – 100 cpm
0.3 – 1 cps

If your background is too high, you must move to another area, re-perform the operational check, and try again. A short in the cable or a contaminated probe can cause elevated backgrounds. Please call the Office of Radiation Safety if high background persists.

Survey Reminders:

- Always remove the red cap (if any) before surveying with GM survey meter.
- Hold the probe approximately one centimeter away from any surface – do not let the probe make contact with the object you are surveying.
- Keep the probe face parallel to the area being surveyed.
- You can never survey too slowly. Recommended survey speeds range from 2-5 cm/second. Keep in mind that the efficiency of your meter varies with the isotope you are trying to detect.
- Always survey with the audio “on”! The audio speaker is sometimes a better indicator of small amounts of radioactivity than the meter reading. At higher count rates, the speaker response is often faster than the meter reading. Listen for an increased audio response before slowing your survey speed and finding the area of greatest contamination.

Sodium Iodide (NaI) Scintillation Detector

Scintillation detectors, which incorporate a sodium iodide (NaI) crystal, are used for the detection of the low energy gamma emitter I-125. Some survey meters allow for the use of both a GM detector and a scintillation detector. The efficiency of a low energy scintillation probe for the detection of I-125 is about 20-30%.

Detection of gamma from I-125

Perform the battery check, operational check, and set the multiplier dial switch to the lowest scale.

The “Instrument Background” is the highest reading when no radioactive material is present. Average background is usually between 200 and 500 cpm. All results are to be recorded in cpm only.

The red cover on the NaI probe is different from that of your end-window or pancake probe and is **not removable**. The probe is quite sensitive and should not be used to assess exposure rates or contamination from isotopes other than I-125. **This probe is used exclusively for the detection of I-125 contamination.**

Liquid Scintillation Counters

The liquid scintillation counter (LSC) is used for the detection of beta-emitters having various energy spectrums. Tritium (H-3) cannot be detected with the GM detector because the electron emitted has a very low energy, therefore, the LSC must be used for analyzing wipe samples from H-3 contamination survey. The instrument records its results in counts per minute (cpm) and the average background is usually less than 50 cpm.

Performing a wipe test

1. Use small pieces of absorbent material (Kimwipe, filter paper, paper towel, cotton-tipped applicator) – approximately 5 cm²
2. The surface area of the object or potentially contaminated workspaces wiped should be approximately 100 cm² (the size of the dollar bill)
3. Wipe all potentially contaminated areas, using an S-shaped pattern to remove dust, dirt, or liquids from the surface
4. Place wipe in an empty vial and add the appropriate type and volume of liquid scintillation cocktail (4ml for a 5 ml vial)
5. A “blank wipe” must be counted to determine instrument background readings. Place a clean piece of absorbent in a vial and add cocktail.
6. Each vial must be counted for 1 minute.
7. LSC protocols must be programmed for detection of the appropriate isotope energies (0 to 18.6 keV in the case of H-3). Many of the newer model LSC’s have a pre-programmed setting for H-3 detection.

Mandatory Radiation Surveys

In order to maintain a safe working environment AND satisfy IEMA regulations, we have two occasions where contamination surveys must be performed in the laboratory. We will identify these surveys as the **Post-experiment Survey** and the **Weekly Laboratory Survey**.

Post-experiment Survey

The Post-experiment survey is done to inspect for contamination after each use of radioactive material. This applies to any handling of unsealed radioactive material, which includes labeled samples, source vials, radioactive waste, and the like. Each person who handles radioactive material in the laboratory is responsible for surveying the area(s) they may have worked in. All equipment that may have been handled during the course of the procedure should be surveyed as well. The individual must survey themselves (hands, feet, lab coat) to ensure that they are contamination free – and that there was no potential for cross-contamination elsewhere in the lab.

The instrument used in performing the survey is dependent upon which isotope was used during the experiment. Refer to the radioactive properties of the isotope(s) used to determine which survey instrument is required.

Example 1: Tritium (H-3) is a beta-emitter whose electrons have a very low maximum energy of 18.6 keV. Because the minimum energy needed to penetrate the window of a GM detector is generally around 70 keV, the efficiency of the detector for H-3 is zero. A liquid scintillation counter wipe test must be performed to detect removable contamination.

Example 2: P-32 is also a beta-emitter, but the emitted electrons have varying energies that may exceed 1700 keV. These electrons easily penetrate the window of the GM detector (P-32 efficiency approaching 30%).

Once all required areas and items have been surveyed, with readings at or below background levels, the Post-experiment Survey is complete. No documentation of this survey is required. It is most important that the survey be performed immediately after radioactive material use, which will decrease the chances of someone else being contaminated in your workspace.

Weekly Laboratory Survey

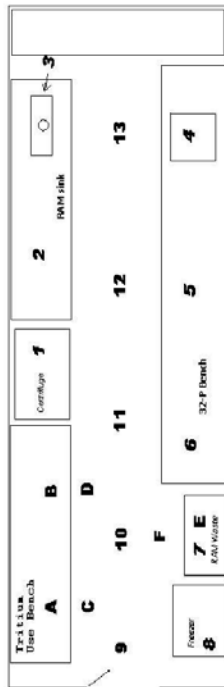
The weekly laboratory survey is usually performed at the end of the workweek and is required whenever a laboratory has used radioactive material during the week. If an isotope (or isotopes) has not been used during the week, no survey is required. **NOTE:** If no survey is required for the given week, the “**NO USAGE**” box must be checked on the survey document on weekly checklist.

As opposed to the post-experiment survey, the weekly laboratory survey must be documented and stored in a binder or folder in your laboratory. The Office of Radiation Safety provides approved forms for properly recording your survey, (Fig. 18). Since your lab may possess more than one radioactive isotope, the weekly survey requires a combination of survey instruments (GM detector with end-window or pancake probe, NaI probed survey instrument, or LSC).

The University of Chicago

Survey Record for Removable Contamination

Principal Investigator: Frankenstein, Frederick	Lab Location(s): TD 123	Date (mm/dd/yyyy): 01/02/2020
(Draw a sketch of the lab. Then mark sketch with survey locations by Numbers, Roman Numerals and/or Letters)		Surveyor Initials: IGR



Survey Instrument:	#1 Manufacturer: Ludlum	Model # 3	Serial # 21454
Circle Probe(s) Used: GM	Crystal	Circle Meter face units for Probe(s):	cpm
#2 Manufacturer:		Model #	mR/hr
Circle Probe(s) Used: GM	Crystal	Circle Meter face units for Probe(s):	cpm
Liquid Scintillation Counter:	Manufacturer: Packard	Model # 8500	Serial # 86753009
Gamma Counter:	Manufacturer:	Model #	Serial #

CHECK FOR USAGE SINCE LAST DOCUMENTED SURVEY BEFORE COMPLETING THE NEXT SURVEY

Prior to completing the survey you should check all Usage and Disposal Logs for any active usage since the last documented survey. A contamination survey must be documented once per week unless radioactive material has not been used since the last documented survey. If there has been no usage since the last documented survey, you only need to date the survey section, initial and check the box to the left of the "NO USAGE since last survey record" noted in the survey sections below. Survey Areas: You should include hands, shoes, labcoat, workbenches, floor of work area, hood, sink, equipment used, storage units, waste storage containers, telephone, etc.)

☐ **NO USAGE** since last survey record

Circle all isotopes used: H-3 C-14 P-32 S-35 Cr-51 I-125 Other: _____

GM Probe*		Nal Probe* (I-125 use only) (cpm)		Wipe Test (cpm) (Record Actual Numbers)		Decontamination Results**	
Inst. Bkg. 0.03		Inst. Bkg.		Inst. Bkg. 43		(use back for additional comments)	
1. ✓	9. ✓	I.	IX.	A. 37	J.	Area 7 measuring 1.5 mR / hr at 32-P waste. Shielded with Plexiglas. New survey reading 0.03 mR / hr.	
2. ✓	10. ✓	II.	X.	B. 551	K.		
3. ✓	11. ✓	III.	XI.	C. 88	L.	Area B measuring 551 cpm on 3-H bench. Cleaned with detergent and water. New survey reading 77 cpm.	
4. ✓	12. ✓	IV.	XII.	D. 56	M.		
5. ✓	13. ✓	V.	XIII.	E. 44	N.		
6. ✓	14. ✓	VI.	XIV.	F.	O.		
7. 1.5	15. ✓	VII.	XV.	G.	P.		
8. ✓	16. ✓	VIII.	XVI.	H.	Q.		
	17. ✓		XVII.				

* A checkmark may signify a background (Bkg) reading. Readings above Bkg must be recorded as numerical values. The "Inst. Bkg." reading must be a numerical value.

** The following survey results require further evaluation and corrective actions: 1) Wipe test > 400 cpm; 2) GM survey instrument reading > 0.25 mR/hr, 600 cpm (6 cps for Mini Monitors and Rad-Monitors that read in cps); 3) Nal survey instrument reading > 1000 cpm.

*** Please note: Any contamination found that is removable from any surface must be cleaned no matter what the survey instrument is reading. Even if the survey instrument reading is above Bkg, but below the action levels noted above.

Fig. 18: Weekly Laboratory Survey Form

A survey must be performed in all areas where radioactive materials were manipulated, transported, or disposed during the course of the week. The following items must be recorded on the survey document:

- Name of the PI
- Isotopes used during the week
- Date of survey
- Room number / description of areas surveyed
- Your initials
- Survey instrument information (manufacturer, model, serial number)
- Instrument background(s)
- Any survey readings > background
- Corrective Actions (for areas with readings > background).

A representative from your lab (usually the Laboratory Designee) is responsible for overseeing the weekly laboratory surveys and maintaining documentation. Each radiation worker is responsible for communicating to the Laboratory Designee which isotopes they handled in a given week, as well as which areas (benches, sinks, etc.) of the laboratory they used.

In the event that you are sharing a workspace with one or more PI's, a single weekly laboratory survey can be performed for the room. Contact your Laboratory Designee to coordinate with all laboratories sharing this space, as each group must maintain copies of the weekly surveys for their records.

Survey Documentation

Areas required to be surveyed must be indicated either by a written description or by drawing a map of the laboratory and assigning numbers to workspaces (see Fig. 18). Notice that in this example, only a small portion of the laboratory was surveyed, since there was no use or storage of radioactive material in the hoods, refrigerators, etc.

Information such as instrument serial numbers, PI's name, room number, and so on can be included on a master copy of the survey document if they will not change from week to week. The date of survey, initials, instrument background, survey results, and decontamination results all must be entered manually from week to week. Do not use a survey form that has these items already filled out!

There are three columns on the bottom of the page, signifying the three survey instruments that may be used, depending on the isotopes used in the laboratory. Each column begins with a space to enter the instrument background – this information must be entered for each survey and requires an actual numerical value. Values corresponding to the points on the map can be entered below. When the measurements are less than or equal to the instrument background, a “checkmark” can be entered in place of the numerical value. Enter the highest measured reading for each surveyed area in the appropriate space in the column.

If all areas measure at or below background levels, date and initial the document and store it in the appropriate binder – your survey is complete! If some areas measure above background levels, you may have to implement a corrective action such as decontamination, disposal of radioactive items, labeling, or shielding to correct the situation. Write a short description of corrective actions taken in the far-right column labeled decontamination results. Survey the area again and record the new measurements below.

Decontamination and Corrective Actions

As we mentioned earlier, survey results reading higher than background levels may require a corrective action. First, we must determine the source of the elevated readings. If the readings are due to source material or radioactive waste in a properly labeled storage unit or container, the action threshold is 0.25 mR/hr. Survey readings above this level require us to move or shield items with elevated reading to reduce the exposure rate to 0.25 mR/hr or less.

Items that are not normally radioactive but give elevated survey readings must be considered *contaminated*. These items must be decontaminated, disposed as radioactive waste, or labeled as radioactive and shielded to reduce exposure rates to background levels.

Working areas such as benchtops, floors, water baths, drawer handles, etc. must measure at background levels at all times. In order to decontaminate an item, you must be wearing the full PPE for radioactive material use. Start with a paper towel and some detergent, warm water, or household cleanser, and scrub the area of the highest elevated readings. If you discovered the contamination with a GM detector, hold the paper towel in front of the probe to determine if the radioactive material is being removed. Once you can no longer detect radiation from the paper towels, re-survey the contaminated area. If the new survey is at or below background levels, your clean-up was successful, and the decontamination is complete. During a weekly survey, you will record a description of your efforts, along with the new survey results, on the Weekly Survey document.

Often you will come across an item that is difficult to completely decontaminate, such as a plastic micropipette or a tabletop centrifuge rotor. Radioactive material may have absorbed into the equipment and cannot be removed with any amount of scrubbing. In these cases, you may label the item with “Caution Radioactive Material” labels. This will require that anyone handling the item in the future **MUST** wear the proper PPE for radioactive material handling (lab coat and disposable gloves). All labeled items must not create an exposure rate to adjacent areas greater than 0.25 mR/hr. Radioactive material causing excessive exposure rates must be shielded, re-positioned (increase the distance from work areas), or properly disposed in order to correct the problem.

Because the background measurements for a wipe test (H-3 detection) can vary wildly, the threshold for contamination has been set at 400 counts per minute (cpm). Any item not labeled as radioactive must be decontaminated, wiped a second time, and the second wipe counted. If the results are now below 400 cpm, the decontamination is complete.

The Sodium-Iodide (NaI) scintillation probe, used whenever I-125 is used or stored in the lab, is highly sensitive and generally useful only for detecting contamination. *Contaminated items* have a decontamination threshold of 1000 cpm. There is NO threshold for exposure from labeled equipment or radioactive material sources when surveying with the Sodium-Iodide probe.

Corrective Action Thresholds due to Contamination

GM Survey: any readings > background for non-RAM labeled items (CONTAMINATION)

Wipe Test: any readings > 400cpm (CONTAMINATION)

NaI probe: any readings > 1000cpm for non-RAM labeled items (I-125 users)
(CONTAMINATION)

Threshold for Corrective Actions due to Excessive Radiation Exposure

GM survey: any readings > 0.25 mR/hr in an occupied space (Including Stored and Labeled RAM)

Fig. 19: Corrective Action Threshold

Preparing Your Experiment

Before actually removing any radioactive material from your source vial, you must prepare your work area properly. Cover the entire workbench with benchcoat paper or using layers of absorbent material. Label the borders of this papered area with “Caution: Radioactive Material” tape. Shielding, temporary waste containers (for liquid or pipette tips), and items such as cuvette racks and gel trays must be labeled “radioactive” as well. Perform the Battery Check and Operational Check on your survey instrument and place it near the edge of the radioactive material work area. Set the indicator dial to the most sensitive scale and point the probe away from the center of the workbench – this will allow you to survey items as they are removed from the bench, while maintaining low background readings. Bring all other materials necessary for your experiment to the bench at this time, if possible. After donning your lab coat and disposable gloves, you are ready to remove the radioactive material from its storage location and bring it to the bench.

Shielding may be required when using isotopes other than H-3 or C-14. Place the source vial behind the shield and survey the areas around the work area. Make sure that any area that a co-worker could inhabit measures less than 0.25 mR/hr. Reposition the source material or utilize additional shielding to reduce exposure rates below the threshold level. You are now ready to begin your experiment.

The amount of radioactive material used in your experiment, as well as the portion remaining in the vial, will be determined by the volume of the liquid removed. Record today’s date and the activity removed on the corresponding ‘Receipt and Disposal Record’ (see Fig. 13). Periodically survey your hands, pipettors, and other items you may be manipulating by holding them up to the GM probe (without actually touching it). If your gloves become contaminated during the course of the experiment, carefully remove them using the inside-out technique, and dispose them to the radioactive waste container. Re-glove and continue. Many workers wear two pairs of gloves, which allow them to quickly continue working after removing the outer pair, limiting further cross-contamination.

Additional Precautions for Specific Radioactive Substances

Certain isotopes and chemical compounds have specific guidelines for handling in a laboratory setting.

Solutions of I-125 having iodine molecules that are not chemically bound **MUST** be manipulated in a Radiation Safety approved, working radioisotope fume hood. The free form of I-125 in NaOH, (not bound to an antibody or ligand), this free form is potentially volatile and may be accidentally inhaled, leading to its uptake by the thyroid gland. RIA kits are exempt from fume hood use.

Anyone using more than 1.0 mCi of I-125 **MUST schedule a thyroid bioassay with the Office of Radiation Safety**. The bioassay must be performed 12 to 72 hours after the iodination. Each user is responsible for scheduling their bioassay in a timely fashion. Bioassays generally take about five minutes and are conducted in the Office of Radiation Safety, M-031A, Billings Hospital.

Stock material of amino acid-bound sulfur compounds S-35, such as methionine, must also be manipulated in an approved, working fume hood. Once the S-35 is incorporated into a culture or sample, the labeled material may be safely handled outside of the fume hood.

Emergency Procedure

In case there is a spill of radioactive material, IEMA Emergency Procedures should be followed. In case of a minor spill, when small volumes, small areas and low activity of radioactive material is involved, follow the IEMA Emergency procedures written in the left column (Appendix A). If large volumes, areas and high activity of radioactive material is involved, use the procedures written in the right column.

APPENDIX A IEMA EMERGENCY PROCEDURE

HOW TO REACH RADIATION SAFETY OFFICE STAFF

Normal Working Hours (M-F, 8:30 am to 5:00 pm)

Call **2-6299** and report that a radioactive spill or radiation incident has occurred.

After Hours, Weekends, Holidays

Call University Police at **2-8181** and report that a radioactive spill or radiation incident has occurred and instruct them to contact Radiation Safety personnel.

LOSS, THEFT, OR DAMAGE OF SOURCES OF RADIOACTIVE MATERIAL

Any loss, theft, or damage to any source of radioactive material (radioactive waste, stock vial solutions, sealed sources, etc.) or any other accident involving radioactive material **must** be reported promptly to the individual responsible for the use of the radioactive material and to the Office of Radiation Safety.

SPILL PROCEDURE

Minor Spill

A minor spill is one that can be readily cleaned without spreading the spill. It involves small volumes, small areas, low activity of radioactive material, no volatile materials, and involves no internal radiation hazard to personnel.

Major Spill

A major spill involves large volumes, large areas, and high activity of radioactive material, volatile materials, contamination of body or clothing, or contamination that has spread or occurred outside the lab or designated area of use.

In the event of a minor spill:

- 1) Notify all persons in the room immediately that a spill has occurred.
- 2) Cover the spill with absorbent material.
- 3) Restrict movement into the area.
- 4) Don two pair of disposable gloves and proceed decontaminating the spill area.
- 5) Insert all clean-up material (i.e. absorbent paper, paper towels, scrub brushes, etc.) into a plastic bag and dispose of contaminated material in the radioactive waste container.
- 6) With a GM survey instrument, survey spill area, hands and clothing for contamination. For alpha and low-energy beta emitters, conduct a wipe test at the spill area.
- 7) Permit no one to resume work in the immediate area of the spill until the contamination has been cleared.

In the event of a major spill:

- 1) Follow steps 1-4 for a minor spill (listed to the left).
- 2) Notify authorized user and Office of Radiation Safety immediately.
- 3) Confine all personnel potentially contaminated to an isolated area in or near lab.
- 4) Monitor all persons involved in the spill.
- 5) Decontaminate personnel by washing the affected area immediately with soap and water or a decontaminating agent effective for the chemical involved. If contamination is localized to a small area of skin, the contamination should be masked off and the affected areas cleaned with cotton applicators dipped in soap or suitable decontamination agents. Care should be taken not to scratch or erode the epidermal skin layer.
- 6) If life threatening injuries are present, the individual should be given immediate life-saving first aid and transported to a hospital. Notification regarding possible contamination of the patient should be communicated to the hospital and emergency responders, if responding.
- 7) All clothing suspected of being contaminated should be removed and isolated for monitoring.
- 8) Proceed in decontaminating the spill area.
- 9) Continue with steps 5-7 for minor spills.

EXPOSURE TO SOURCES OF RADIATION

- 1) Terminate the source of exposure and prevent others from being exposed. Use additional shielding as needed to minimize the radiation exposure.
- 2) Immediately notify the Radiation Safety Officer (RSO) and individual responsible for the use of the radioactive material.
- 3) Seek medical attention if severe exposure is suspected.

APPENDIX B

Waste Instruction Labels

AQUEOUS WASTE LIQUID (AQUEOUS) WASTE MANIFEST # A-XXXXX

Contamination Control

Always wear gloves when handling this carboy. Aqueous waste containers often have external contamination on the spout, sides and bottom.

Spill Control

Place this carboy on/in a tray or other container, which will effectively contain any spills, drips, or leakage. Call Radiation Safety with issues.

One Isotope Only

Use this carboy only for the isotope(s) indicated on the waste manifest.

DO NOT MIX ISOTOPES unless approved by Radiation Safety!

Request additional carboys if needed.

Manifest

Record the date (MM/DD/YY) and approximate activity (μCi) of each addition to this carboy on the attached MANIFEST FORM.

Approved Liquids

Aqueous solutions of non-hazardous chemicals (EPA listed) in the pH range of 4-10. Call Radiation Safety if you have questions or need proper containers.)

Forbidden Substances

- * Organic liquids (including scintillation fluids);
- * Biohazards (infection hazard material); **NOTE:** do not attempt disinfection with bleach (sodium hypochlorite solution) without prior consultation with Radiation Safety.
- * Hazardous, flammable, pyrophoric or explosive substances.

Call Radiation Safety if you have questions about proper disposal of these substances.

Pickup and Delivery

DO NOT OVERFILL CONTAINERS!

Call Radiation Safety at 2-6299 or

Email: radsafety@uchicago.edu

COMPACTABLE DRY SOLID WASTE MANIFEST # C-XXXXX

No Liquids

Only incidental quantities (less than 1 ml) of aqueous liquids may be present.

One Isotope Only

Use this container only for the isotope(s) indicated on the waste manifest. **DO NOT MIX ISOTOPES!** Special needs or exceptions can be made by calling Radiation Safety.

Manifest

Record the date (MM/DD/YY) and approximate activity (μCi) of each addition to this container on the attached MANIFEST FORM.

Continuation Sheets are available, if needed.

Approved Items

Glass, Metals (including aluminum foil and sharps properly contained), PVC plastics. (Consult Radiation Safety for complete list.)

Forbidden Items

Organic liquids (including scintillation fluids), Manufacturer's stock solution vials; Biohazards (infection hazard material); Hazardous, flammable, pyrophoric or explosive substances.

Pickup and Delivery


DO NOT OVERFILL CONTAINERS!

Call Radiation Safety at 2-6299 or

Email: radsafety@uchicago.edu

SHORT-LIVED ISOTOPES DRY SOLID WASTE MANIFEST # D-XXXXX

Deface Labels

All Radioactive Material warning labels and  symbols must be defaced or removed **BEFORE** they are placed in the container.

No Liquids

Only incidental quantities (less than 1 ml) of aqueous liquids may be present.

One Isotope Only

This container is to be used only for the isotope(s) indicated on the waste manifest. **DO NOT MIX ISOTOPES!** This container is for ^{32}P , ^{33}P , ^{35}S , ^{51}Cr , ^{125}I and other isotopes with a half-life of less than 120 days. Special needs or exceptions can be made by calling Radiation Safety.

Manifest

Record the date (MM/DD/YY) and approximate activity (μCi) of each addition to this container on the attached MANIFEST FORM. Continuation Sheets are available, if needed.

Forbidden Items

Long-lived isotopes such as ^3H (tritium) and ^{14}C ; Organic liquids (including scintillation fluids); Manufacturer's stock solution vials and Lead pigs; Hazardous, flammable, pyrophoric or explosive chemicals and substances.

Pickup and Delivery

DO NOT OVERFILL CONTAINERS!

Call Radiation Safety at 2-6299 or
Email: radsafety@uchicago.edu

INCINERABLE DRY SOLID WASTE MANIFEST # I-XXXXX

No Liquids

Only incidental quantities (less than 1ml) of aqueous liquids may be present.

One Isotope Only

Use this container only for the isotope(s) indicated on the waste manifest. **DO NOT MIX ISOTOPES!** Special needs or exceptions can be made by calling Radiation Safety.

Manifest

Record the date (MM/DD/YY) and approximate activity (μCi) of each addition to this container on the attached MANIFEST FORM. Continuation Sheets are available, if needed.

Approved Items

Paper, most plastics, latex gloves, nitrile gloves, cloth, etc.

Forbidden Items

Glass, Metals (including aluminum foil, lead pigs, and sharps); Organic liquids (including scintillation fluids); Stock solution vials; Biohazards (infection hazard material); Hazardous, flammable, pyrophoric or explosive substances.

Pickup and Delivery

DO NOT OVERFILL CONTAINERS!


Call Radiation Safety at 2-6299 or
Email: radsafety@uchicago.edu

SCINTILLATION VIALS

SCINTILLATION VIAL WASTE

MANIFEST # L-XXXXX

Deface Labels

All Radioactive Material warning labels and  symbols must be defaced or removed **BEFORE** they are placed in the container.

One Isotope Only

Use this container only for the isotope(s) identified on the waste manifest. **Do not mix isotopes unless approved by Radiation Safety.**

Radioactivity Limits

Regulated Activities for Scintillation Vials

- * Isotopes such as ^{32}P , ^{33}P , ^{35}S , ^{51}Cr , etc., with activities **above background** levels; AND
- * Scintillation vials with ^3H , ^{14}C , and ^{125}I activities **exceeding 0.05 microcuries per milliliter of scintillation medium.**

Unregulated Activities for Scintillation Vials

Scintillation vials with ^3H , ^{14}C , and ^{125}I activities **less than 0.05 microcuries per milliliter of scintillation medium.** These vials shall be disposed via the chemical waste vendor by contacting the appropriate Safety Office for the Hospital or University laboratories.

Calculating Sample Activity

Isotope	Volume	Efficiency	Maximum CPM for Disposal	Resulting Activity $\mu\text{Ci}/\text{ml}$
3-H	1ml	50%	51500	0.047
14-C	5ml	50%	275000	0.05
125-I	10ml	50%	550000	0.05

Manifest

Record the date (MM/DD/YY) and approximate activity (μCi) of each addition to this container on the attached MANIFEST FORM.

Pickup/Delivery

DO NOT OVERFILL CONTAINERS!


Call Radiation Safety at 2-6299 or Email: radsafety@uchicago.edu

STOCK VIALS

STOCK VIAL WASTE

MANIFEST # S-XXXXX

Deface Labels

All Radioactive Material warning labels and  symbols must be defaced or removed **BEFORE** they are placed in the container.

Isotope Stock Vials Only

No other waste should be placed in this container.

One Isotope Only

Use this container and manifest only for the isotope(s) indicated on the waste manifest. **DO NOT MIX ISOTOPES!** Special needs or exceptions can be made by calling Radiation Safety.

Manifest

Record the date (MM/DD/YY) and approximate residual activity (μCi) of each vial added to this container on the attached MANIFEST FORM. Record the Manifest number onto the Radionuclide Receipt & Disposal Record for the stock vial being disposed.

Pickup and Delivery

DO NOT OVERFILL CONTAINERS!

Call Radiation Safety at 2-6299 or

Email: radsafety@uchicago.edu