

# ***Radiation Safety Guide***

## ***Research Use of Radioactive Materials***

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## RADIATION AND RADIOACTIVITY

Atoms are the basic building blocks of matter. An atom itself is made up of electrons, protons and neutrons. A proton has a positive charge of one and has a mass of about 1 atomic mass unit or amu ( $1.7 \times 10^{-27}$  kg). A neutron is electrically neutral and has a mass of about 1 amu. Electrons carry a negative charge and have a mass of only 0.00055 amu. Protons and neutrons in an atom reside in its nucleus, while the electrons revolve in various orbits around the nucleus. A neutral atom has the same number of electrons as the number of protons in its nucleus. The number of protons in an atom is called its atomic number (Z), while the total number of protons and neutrons in an atom is called its mass number (M). In scientific literature, an atom is specified by its chemical symbol and its mass number. For example, an atom of phosphorus with mass number 32 is designated as P-32. It is possible for two atoms of the same element to have different mass numbers. For example, C-12 and C-14 are atoms of the same element (carbon), but have different mass numbers (12 and 14). They are called isotopes of carbon. Except for a few lighter atoms, the number of protons and neutrons in an atom is not the same. In fact, in most stable atoms, there are more neutrons than there are protons. The chemical properties of an atom are determined by its atomic number and not its mass number. For example, C-12 and C-14 have different mass numbers but have identical chemical properties.

An atom with an excess or deficiency of neutrons is unstable and it may become stable by emitting radiation. Such unstable atoms are called radioactive. Transition of an atom from an unstable state to stable state is called radioactive decay. For example, C-14 has two neutrons more than does C-12, which is the stable form of carbon. C-14 achieves stability by emitting an electron, and the resulting atom is nitrogen-14, which is stable. The emitted electron is called the  $\beta$ -particle. Unstable atoms may become stable by emitting one or more of  $\alpha$ -particles,  $\beta$ -particles and/or  $\gamma$ -rays. Stability may be achieved in one step or in several steps until a stable atom is reached.  $\alpha$ -Particles and  $\gamma$ -rays are called nuclear radiation because they originate from the nucleus of the atom. Emission of an  $\alpha$ -particle or a  $\beta$ -particle results in a different atom. The original atom is called the parent atom while the resulting atom is called the daughter product.

$\beta$ -particles are either positive or negative electrons, while  $\alpha$ -particles are nuclei of helium and are composed of 2 protons and 2 neutrons bound together.  $\gamma$ -Rays are bundles of energy. These bundles of energy are called photons. They are similar to x-rays, and visible light, which are emitted when atomic electrons move from one orbit to another.  $\gamma$ -rays, x-rays, and visible light are different forms of electromagnetic radiation.  $\alpha$ -particles are the least penetrating of the three forms of nuclear radiation while the  $\gamma$ -rays are the most penetrating.  $\alpha$ -particles,  $\beta$ -particles and  $\gamma$ -rays interact with matter and can disrupt chemical bonding. When any one of these radiations interacts with matter, it can remove one or more electrons from atoms in the material, thereby leaving the atoms deficient in electrons. This phenomenon is called ionization. That is why these types of nuclear radiation ( $\alpha$ -particles,  $\beta$ -particles and  $\gamma$ -rays) are also called ionizing radiation. This characteristic of this ionizing radiation makes it hazardous to health. Visible light does not have sufficient energy to cause ionization. Visible light is one example of non-ionizing radiation.

### ***A. Decay by Alpha ( $\alpha$ )-Particle Emission***

An unstable atom may decay to a stable atom by the emission of an  $\alpha$ -particle. In this case the atom has lost two neutrons and two protons and therefore, its atomic number (Z) decreases by 2 and its mass number (M) decreases by 4. This mode of decay occurs in heavy elements like uranium, thorium, polonium, etc.

Alpha particles have very little penetrating power because of their large mass and can be stopped by the first dead layer of skin, few inches of air, or a sheet of paper. They do not present a significant external hazard because of their low penetrating power. However, inside the body, they can be hazardous to living cells. They can inflict serious biological damage inside the body, because they give up their energy over a relatively short distance.

### ***B. Decay by Beta ( $\beta$ )-Particle Emission***

An unstable atom may reach a stable state by the emission of a positive or a negative electron. A positive electron is also called a positron. In one mode of decay a neutron is converted into a proton and an electron. The electron is ejected from the nucleus. The atomic number ( $Z$ ) of the resulting atom is increased by one and the mass number ( $M$ ) remains unchanged. Alternatively, a proton within the nucleus is converted into a neutron and a positron. The positron is ejected from the nucleus. The atomic number ( $Z$ ) of the resulting atom is decreased by one while the mass number ( $M$ ) remains unchanged. The emission of a beta particle is accompanied by emission of a neutrino or an antineutrino. These neutral particles are almost massless and therefore can travel in matter long distances before any interaction with matter. Beta particles are much smaller than alpha particles and therefore their interaction with matter is not the same as alpha particles. They are more penetrating than alpha particles. Depending upon their energy, beta particles can travel several meters in air, and a few centimeters in water or in human tissue. They can be stopped by thin layers of metal or plastic.

### ***C. Decay by Gamma Ray ( $\gamma$ ) Emission***

An unstable atom may reach a stable state by the emission of one or more gamma rays. Decay by alpha or beta particle emission almost always is accompanied by emission of one or more gamma ray photons. Like all forms of electromagnetic radiation, the gamma ray photon has no mass or charge. Gamma rays may interact with electrons in an atom that may result in ionization of the atom. They lose their energy slowly in material, and are able to travel significant distances before losing all of their energy. Depending upon their energy, gamma rays can travel for several meters in air and can easily pass through the human body.

### ***D. Decay by Electron Capture (X-rays)***

An unstable atom may reach a stable state when its nucleus captures one of the orbiting electrons. In this mode of decay, the captured electron neutralizes one of the protons in the nucleus and therefore the atomic number ( $Z$ ) of the resulting atom decreases by one while its mass number ( $M$ ) remains unchanged. An electron from an outer orbit may fill in the position of the captured electron by the emission of a photon. This photon is identical to a gamma ray photon but is called an x-ray photon because it has its origin outside of the nucleus, whereas gamma rays originate from within the nucleus.

### ***E. Other Sources of Radiation***

When electrons travel in a medium, they slow down because of interaction with atomic electrons and nuclei in the medium. Slowing electrons lose their energy that is radiated in the form of x-rays. These x-rays are called Brehmstrahlung Radiation. This radiation does not have a fixed energy but consists of a band of energy. X-rays are also produced when atomic electrons from inner orbits are ejected and their place is taken by electrons from outer orbits of the atoms. Such x-rays have fixed energy characteristics of the atom from which they originate. That is why these x-rays are called characteristic x-rays.

X-rays are identical to  $\gamma$ -rays. The different names are given because of their origin. As discussed earlier, gamma rays originate from atomic nuclei, while the x-rays have their origin in atomic electrons that circle around the nucleus.

Heavy elements like lead have more electrons around their nuclei than lighter elements like hydrogen, or carbon. When a beta particle from phosphorus  $^{32}$  strikes a lead shield, it will encounter much more electrons than when it strikes plastic material that is composed of lighter elements. The beta particle may interact with this cloud of electrons in lead and produce more Bremsstrahlung than when it strikes a plastic material where it will encounter a much smaller cloud of electrons. This is the reason that heavy material is not used for shielding high energy beta particles and the plastic material is preferred shielding. Lead may be added as secondary radiation shield outside of Plexiglas if exposure is still high.

#### *F. Neutron particles (n)*

Neutrons are neutral particles that are part of nuclei. They are very penetrating because they do not carry electric charge and are slowed down by collisions with nuclei. Neutrons are produced when a nucleus of a heavy element, like uranium or plutonium splits because of excess neutrons. This phenomenon is called fission. Nuclear power reactors utilize fission properties of these nuclei to produce energy. The slowing down of neutrons is more rapid when they collide with smaller nuclei like those of hydrogen and carbon, etc. That is the reason for using water or paraffin wax as a shielding for neutrons.

#### *G. Radiation Quantities*

**Exposure** is a measure of the ionization produced in air by x or  $\gamma$  radiation. The conventional unit of exposure is roentgen(R) and the international unit (SI) of exposure is Coulombs/Kilogram.

**Radiation effect** on any material is determined by the radiation “dose” that is received by the material. **Radiation dose** is the quantity of radiation energy deposited in a material. **Absorbed dose** is the amount of energy deposited in any material by the ionizing radiation. Absorbed dose is measured in rads. A rad, is a measure of energy absorbed per gram of material. The SI unit of absorbed dose is the gray which is 0.01 rad. **Dose Equivalent** is a measure of the effectiveness of the absorbed dose. It expresses the effect of all radiation on a common scale for calculating the effective absorbed dose. The unit of Dose Equivalent is rem, which is defined as the product of absorbed dose and the quality factor of radiation. The quality factor for x-rays, gamma rays, and electrons is 1, while for thermal neutron it is 5 and for neutrons, protons and  $\alpha$  particles is 10. SI unit of dose equivalent is sievert.

It is customary to refer to the quantity of radioactive materials based on its activity. The activity is simply the number of nuclear disintegration or transformations the quantity of material undergoes per second. The activity is measured in curies (Ci). The SI unit for activity is Becquerel (Bq).

The conversion between conventional unit and SI unit is listed below:

Quantity	Conventional unit	(SI) unit	Conversion
Exposure	roentgen (R)	Coulomb/Kg of air (C/kg)	1 C/kg = 3876 R 1R = 2.58X10 <sup>-4</sup> C/kg
Dose	rad (100 ergs/g)	gray (Gy)	1 Gy = 100 rad 1cGy = 10 <sup>-2</sup> Gy = 1 rad
Dose equivalent	rem (rad X quality factor(Q))	sievert (Sv) (Gy X Q)	1 Sv = 100 rem
Activity	Curie, disintegration/minute (dpm)	Bacquerel (Bq)	1 Ci = 37000 MBq 1 Ci = 3.7X10 <sup>10</sup> Bq 1 Ci = 2.2X10 <sup>12</sup> dpm

The Research environment generally involves low levels of radiation. The following table summarizes the smaller units that are commonly used in these environments.

Quantity	unit	conversion
Exposure	milliroentgen (mR)	0.001 R
Dose	millirad (mrad)	0.001 rad
Dose equivalent	millirem (mrem)	0.001 rem
Activity	milliCi ( mCi)	0.001Ci

#### H. Half-life, Biological half-life, Effective half-life

Radioactive atoms decay randomly but at a characteristic rate. The decay times, the number of steps in the decay, and the kind of radiation released at each step are well known.

The time required for half of the material to decay is called its Half-life and is designated by T<sub>1/2</sub>. Each radioactive isotope has its own characteristic half-life. Half-lives can range from less than a millionth of a second to millions of years depending upon the isotope. The number of atoms of a radioactive material remaining after a time (t) is calculated by the following relationship:

$$A=A_0 e^{(-0.693 \cdot t)/T_{1/2}},$$

where A<sub>0</sub> is the original number of atoms.

Example: <sup>32</sup>P has a half-life of 14 days. If the initial amount of <sup>32</sup>P is 2 millicuries, after one week the amount of <sup>32</sup>P remaining is calculated by

$$A= 2(\text{mCi}) * e^{(-0.693 \cdot 7(\text{days})/14 (\text{days}))} = 2(\text{mCi}) * 0.709 = 1.41 \text{ mCi}$$

Biological half-life is the time required for the body to eliminate one half of the material taken in by natural biological means. This half-life is designated by T<sub>1/2 B</sub>. Biological half-life does not depend upon whether the element is radioactive or not. Iodine –131 has half-life of 8 days, but the biological half-life of iodine in the thyroid is 80.4 days.

Effective half-life (T<sub>1/2 eff</sub>) is the time required for a radionuclide in a biological system, such as human or animal organ, to reduce its activity by one-half. This reduction includes decay of the radioisotope and biological elimination. The effective half-life can be calculated by using the following formula:



$$1/T_{1/2 \text{ eff}} = 1/T_{1/2} + 1/T_{1/2 \text{ B}}$$

Example: The effective half-life for I-131 in the thyroid is calculated as

$$1/T_{1/2 \text{ eff}} = 1/8 + 1/80.4 = 0.137,$$

therefore

$$T_{1/2 \text{ eff}} = 7.3 \text{ days}$$

## ***I. Radiation Detection Instruments***

Detection of contamination and monitoring of exposure must be performed by the use of an appropriate survey instrument. No single instrument is capable of measuring all types of radiation. The survey instruments most frequently used at Temple are two types:

### **1. Gas-filled detectors**

The most common type of instrument used for detection of ionizing radiation is a gas filled radiation detector. This instrument works on the principle that as radiation passes through the gas in the chamber it ionizes the gas molecules and produces positive and negative ions. A high voltage is placed between two areas of the gas filled space. Positive ions will be attracted to the negative side of the detector called the cathode and negative ions (electrons) will be attracted to positive side of detector called the anode. The collected charges on the anode and cathode produce a small pulse of charge. This pulse is displayed as a signal. The intensity of the pulse depends upon the radiation that is entering the gas in the chamber.

There are many types of gas-filled detectors, but the two most common are the ion chamber used for measuring radiation exposure, and the Geiger-Muller (GM) detector or counter, that is used to detect and measure small amounts of contamination.

### **2. Scintillation Detector**

This instrument uses a special material that produces light or scintillates when it interacts with radiation. The two most common types of scintillation detectors are a scintillation crystal and a liquid scintillation counter (LSC). The common material used in scintillation crystal detection is sodium-iodide (NaI). The LSC uses a liquid medium that scintillates when radiation interacts with it. The light produced from the scintillation process is reflected through a clear window where it interacts with a device called a photomultiplier tube. The first part of the photomultiplier tube is made of special material called a photocathode. The photocathode produces electrons when light strikes its surface. These electrons are then pulled towards a series of plates called dynodes through the application of a positive high voltage. When electrons from the photocathode hit the first dynode, several electrons are produced for each initial electron hitting its surface. These electrons are then pulled towards the next dynode, where more electrons (multiplication) are produced. The sequence continues until they reached the last dynode. This process amplifies the electron pulse several millions times. The pulse is then detected and displayed by a special instrument.

Table below provides a list of instruments and their uses:

<b>Portable Instruments Used for Detection of Contamination and Ambient Radiation Surveys</b>			
Detectors	Radiation	Energy Range	Efficiency
Ionization Chamber	Gamma, X-ray	$\mu$ R-R	N/A
Count Rate Meters			
GM	Alpha	All energies (dependent on window thickness)	Moderate
	Beta	All energies (dependent on window thickness)	Moderate
	Gamma	All energies	< 1%
NaI Scintillator	Gamma	All energies (dependent on crystal thickness)	Moderate
Plastic Scintillator	Beta	C-14 or higher (dependent on window thickness)	Moderate
<b>Stationary Instruments Used to Measure Wipe, Bioassay, and Effluent Samples</b>			
Detectors	Radiation	Energy Range	Efficiency
Liquid Scintillation Counter (LSC)	Alpha	All energies	High
	Beta	All energies	High
	Gamma		Moderate
Gamma Counter (NaI)	Gamma	All energies	High
Gas Proportional	Alpha	All energies	High
	Beta	All energies	Moderate
	Gamma	All energies	< 1%

### ***J. Background Radiation***

Radiation is occurring naturally in the environment. The sources of this radiation include radon in the air, naturally occurring radioisotopes, and cosmic rays from outer space. We are constantly exposed to this radiation. This is commonly called naturally-occurring background radiation.

The average background radiation exposure to an individual in the United States is about 300 mrem per year. Background radiation varies from area to area. For instance, Colorado has higher radiation levels because its high altitude receives higher dose of cosmic radiation, and its uranium rich soil produces more radiation. Brick homes have higher natural radiation levels than homes made of other materials such as wood; domestic water supplies contain radon; and certain foods such as bananas and Brazil nuts contain higher levels of radioisotope than other foods. The highest known level of background radiation affecting a substantial population is in Kerala and Madras States in India where some 140,000 people receive an annual dose rate which averages over 1500 mrem per year from

gamma radiation, plus a similar amount from radon. Comparable levels occur in Brazil, Iran and Sudan, with average exposures up to 3800 mrem/yr. Four places are known in India and Europe where natural background radiation gives dose rates of more than 5000 mrem per year. No adverse health effects have been discerned from doses arising from these higher levels of natural radiation. In addition, consumer products such as tobacco, fertilizer products and coal have noticeable concentrations of naturally occurring radionuclides including potassium-40.

### ***K. Biological Effects of Radiation***

Biological effects of radiation on living cells may result in three outcomes:

- cells repair themselves, resulting in no damage;
- cells die, much like millions of body cells do every day, being replaced through normal biological processes; or
- cells change their reproductive structure.

The effects of radiation, like those of most chemical substances, can be seen clearly only at doses much higher than are allowed by Federal and State regulations.

Biological effects of radiation may be classified as prompt or delayed effects. Prompt effects can appear in a matter of minutes to as long as a few weeks after exposure to very high doses of radiation. The higher the dose, the sooner the effects will appear, and the higher the probability of death. For example, in 1986, firefighters battling the fire at the Chernobyl nuclear power plant in the Ukraine died from very large doses of approximately 1,100,000 millirads of radiation.

It is not always possible to determine the amount of fatal dose because radiation affects different people in different ways. However, it is believed that 50% of a population would die within thirty days after receiving a dose of between 250,000 to 450,000 mrem over a period of a few minutes to few hours. This would vary depending upon the health of the individuals before the exposure and the medical care received after the exposure. These are acute whole body doses, meaning that the whole body is exposed to the radiation in a very short period of time (minutes to hours). Exposure of only parts of the body will likely lead to more localized effects, such as skin burns or tissue damage in the exposed area.

Delayed effects of radiation are effects that appear many years (usually between 5-20 years) after exposure. The period before cancer appears is known as the latent period. Genetic effects and the development of cancer are the primary health concerns. The cancers that may develop as a result of radiation exposure are indistinguishable from those that develop spontaneously or as a result of exposure to other carcinogens. Radiation exposure may be only the initiating step that may or may not eventually lead to cancer. Genetic effects may appear in the exposed person's direct offspring, or may appear several generations later, depending on whether the altered genes are dominant or recessive.

Although radiation is known to cause cancers at high doses and high dose rates, currently there are no data to unequivocally establish the occurrence of cancer following exposure to low doses and dose rates below about 20,000 mrem. Studies of a population exposed to chronic low-levels of radiation above normal background have shown no biological effects. This population includes occupationally exposed radiation workers and people living in areas having high levels of background radiation above 1,000 mrem per year.

## Principles of Radiation Safety

Exposure of members of the public and workers can be minimized by the use of good safety practices, adequate training of users of radiation or radioactive material, and appropriate equipment. The following practices are a must in efforts to minimize exposure:

- Minimize the external radiation exposure by increasing the distance of the individual from the source of radiation. Keep in mind that the intensity of any radiation field is reduced by a factor of four when the distance from the radiation source is doubled.
- Minimize the time spent near the source of radiation or in the radiation field. The longer the time, the higher is the dose received.
- Wear protective clothing like a lab coat and disposable gloves, and if necessary an eye shield to eliminate the possibility of personal contamination.
- Use an appropriate shielding device such as a Plexiglas shield for P-32 or a leaded L-block for I-131 to minimize the exposure.

### A. *Occupational Dose Limits*

The annual dose limit for occupational radiation workers is 5,000 mrem for whole body, 15,000 mrem for the lens of the eye and 50,000 mrem for organs (e.g. breast, lung), skin and extremities. These limits include exposure from all sources.

### B. *Public Dose*

The radiation dose received by individual members of the public can not exceed 1 millisievert (mSv) [100 millirem (mrem)] in one calendar year. In addition the radiation dose in unrestricted areas can not exceed 0.02 mSv (2 mrem) in any one hour. Air emissions of radioactive materials must not result in doses greater than 0.1 mSv (10 mrem) TEDE per year.

### C. *Dose to an Embryo/Fetus*

The National Council on Radiation Protection and Measurements (NCRP) has recommended limits for radiation exposure to an embryo/fetus. The Department of Environmental Protection of the State of Pennsylvania (PA) have set limits for radiation exposure to the embryo/fetus of a declared pregnant woman. The PA require that the dose to an embryo/fetus during the entire pregnancy, from occupational exposure of a declared pregnant woman, must not exceed 500 mrem. Efforts must be made to assure that this dose is distributed uniformly over the entire period of pregnancy.

A pregnant employee is highly encouraged to voluntarily inform her employer, in writing, of her pregnancy and the estimated date of conception. Further, such an employee is encouraged to visit the Radiation Safety Department and receive information regarding concerns she may have about radiation exposure during pregnancy. Such an employee may discuss her concerns with the Health Physicist.

Upon submission of a completed “Declaration of Pregnancy” form (available at the Radiation Safety Department, 3307 N. Broad Street, # B 49), the Radiation Safety Department will:

- Evaluate the exposure history of the individual and her coworkers;

- Provide information concerning risk and precautions;
- Evaluate the working environment with respect to radiation exposure;
- Make recommendations for reducing radiation exposure;
- Monitor monthly radiation exposure with respect to the PA limits.

#### ***D. Registration of Radiation Workers***

The Department of Environmental Protection of the State of Pennsylvania (DEP) regulations require that individuals who work with radioactive materials are provided training prior to working with radioactive materials or in environment where radioactive material or radiation is present. Workers who have the potential of receiving doses in excess of 10% of regulatory limits are required to be monitored for exposure to radiation. In addition, Temple University policy requires that all radiation workers register with EHS. A Radiation Worker Registry is maintained by EHS in order to ensure that these regulatory requirements are met. Authorized users are required to register workers who are using radioactive materials under their supervision. (Appendix A)

#### ***E. Personal Monitoring***

The Radiation Safety Department provides personal monitoring devices to monitor exposure of workers to radiation. Dosimeters are provided to adult radiation workers who are likely to receive an annual total effective dose equivalent (TEDE) of 500 mrem (5 mSv) and to minors or to Declared pregnant women who are likely to receive an annual TEDE of 50 mrem.

Exposure of a personnel monitoring device to deceptively indicate a dose delivered to an individual is prohibited and is a violation of Pennsylvania Department of Environmental Protection regulation. (PA 221.11.j). PADEP regulations also prohibit such deliberate misconduct.

#### ***F. Types of Dosimeters***

Workers may be provided appropriate monitoring devices (dosimeters) depending upon the type and quantity of material they use. For example, whole body and ring badges are provided to individuals who handle large quantities of gamma and beta emitting isotopes (nuclear medicine technologists, radiation oncologists, individuals who use more than 2 millicuries of phosphorus-32, etc.). Individuals who use more than 1 mCi of low energy gamma (<100 keV) emitting isotopes, or more than 100 uCi of high energy gamma (>100 keV) isotopes are provided with whole body monitors. Dosimeters are exchanged at a frequency that is determined by the RSO. A NVLAP-accredited commercial vendor processes the monitoring devices.

#### ***G. Dosimeter Placement***

Interpretation of the measured dose depends on the placement of the dosimeter. All personnel must wear their dosimeters correctly. The whole body radiation badge must be worn at collar level on the lab coat. Ring Dosimeters are to be worn on the hand that receives the maximum exposure.

Dosimeters are sensitive to extreme heat. Store dosimeters in an area away from any radiation source. Dosimeters must be returned to EHS promptly at the end of the interval specified by the RSO. Individuals who are late in returning their dosimeters will be fined and repeated non-

compliance will be referred to the RADIATION SAFETY COMMITTEE (RSC) for further disciplinary action.

**H. Internal Monitoring**

EHS performs two types of bioassays to monitor potential ingestion, inhalation or absorption of radioactivity into the body. These tests are analyses of urine specimen and in-vivo thyroid counting. Normally an individual is requested for such bioassays only if he/she conducts certain types of experiments or procedures with volatile radionuclides. Radiation workers are required to participate in the bioassay program subsequent to performance of specific procedures as listed in the table below:

Isotope	Nature of Use	Form	Activity mCi
I-131	Radiopharmaceutical Therapy	NaI	200
I-125, I-131	Working in open room or bench	Unbound	1
		Bound to a non-volatile agent	10
	Working in EHRS-approved fume hood	Unbound Form	10
		Bound to a non-volatile agent	100
H-3	Working in open room or bench	Tritiated Compounds	100
		Tritium Gas	100,000
	Working in EHRS-approved fume hood	Tritiated Compounds	1000
		Tritium Gas	1,000,000
	Working in a closed glove box or similar equipment	Tritiated Compounds	10,000
		Tritium Gas	10,000,000

A worker is required to participate in the bioassay program if he/she has the potential of receiving an intake in excess of 10% of the Annual Limit of Intake. Bioassay, if required should be performed within 3 days of the use of I-131, and within 3 weeks of the use of I-125 or tritium.

**I. Exposure Reports**

All individuals who are badged receive their respective exposure reports annually. Exposure report is available at EHS for individuals who wish to review their exposure. The EHS reviews exposure reports and all high or unusual exposures are investigated and a report is provided to the RSC along with the result(s) of the investigation.

**J. ALARA**

This policy provides specific guidance and data on Temple University’s approach to the implementation of the ALARA principle. The EHS reviews personnel exposures on a regular basis. A written report is provided to the RSC that includes any abnormal exposures or those exceeding ALARA Levels I and II, and the results of the subsequent investigation by the EHS of such exposures. ALARA Level I and II are stated below:

ALARA	Notification mrem/m	Level I		Level II		
		mrem/y	mrem/Q	mrem/y	mrem/m	mrem/Q
Whole body	40	480	120	1440	120	480
Lens of Eye	125	1500	375	4500	375	1125
Extremities , Skin, any organ/tissue	400	4800	1200	14400	1200	3600

EHS evaluates the cause of radiation exposure above ALARA limits and present it to the RSC, with the request to provide guidance to EHS for possible corrective actions. EHS in turn implements the recommendations of the RSC. In every case, the investigator will be asked to take steps to reduce the radiation exposure unless the investigator can demonstrate that all reasonable measures were utilized to keep the radiation exposure ALARA.

### ***K. Posting***

To alert personnel of the presence of radioactive materials and potential radiation hazards caution signs and labels should be posted for the following:

- Areas or rooms that contain radioactive materials must be posted with a “**CAUTION, RADIOACTIVE MATERIAL**” sign.
- Containers of radioactive materials must be labeled with a “**CAUTION, RADIOACTIVE MATERIAL**” label. The label must also indicate the radionuclide(s), activity, assay date, and/or other information (e.g., radiation level) to permit appropriate precautions to minimize radiation exposure.
- Radiation Areas:  
Any area, accessible to individuals, in which radiation levels could result in an individual receiving a dose equivalent in excess of 5 mrem (0.05 mSv) in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates should be posted with a “**CAUTION, RADIATION AREA**” sign.
- High Radiation Areas:  
Any area, accessible to individuals, in which radiation levels from radiation sources external to the body could result in an individual receiving a dose equivalent in excess of 100 mrem (1 mSv) in 1 hour at 30 centimeters from the radiation source or 30 centimeters from any surface that the radiation penetrates should be posted with a “**CAUTION, HIGH RADIATION AREA**” sign.
- Very High Radiation Areas:  
Any area, accessible to individuals, in which radiation levels from radiation sources external to the body could result in an individual receiving an absorbed dose in excess of 500 rads (5 grays) in 1 hour at 1 meter from a radiation source or 1 meter from any surface that the radiation penetrates should be posted with a “**GRAVE DANGER, VERY HIGH RADIATION AREA**” sign.
- Areas where airborne radioactivity is present:  
Areas where radioactive material dispersed in the air in the form of dusts, fumes, particulates, mists, vapors, or gases in excess of the derived air concentrations specified in the DEP regulations must be posted with a “**CAUTION, AIRBORNE RADIOACTIVITY AREA**” sign.

- The Commonwealth of Pennsylvania Department of Environmental Protection “ Notice to Employees” must be posted in each laboratory where radioactive material is used or stored. Appendix B is a copy of this form.

EHS maintains a supply of caution signs and labels for posting areas and rooms. Note that most caution labels and signs have specific color and design requirements; therefore, approval of EHS is required for any custom or hand-made signs.

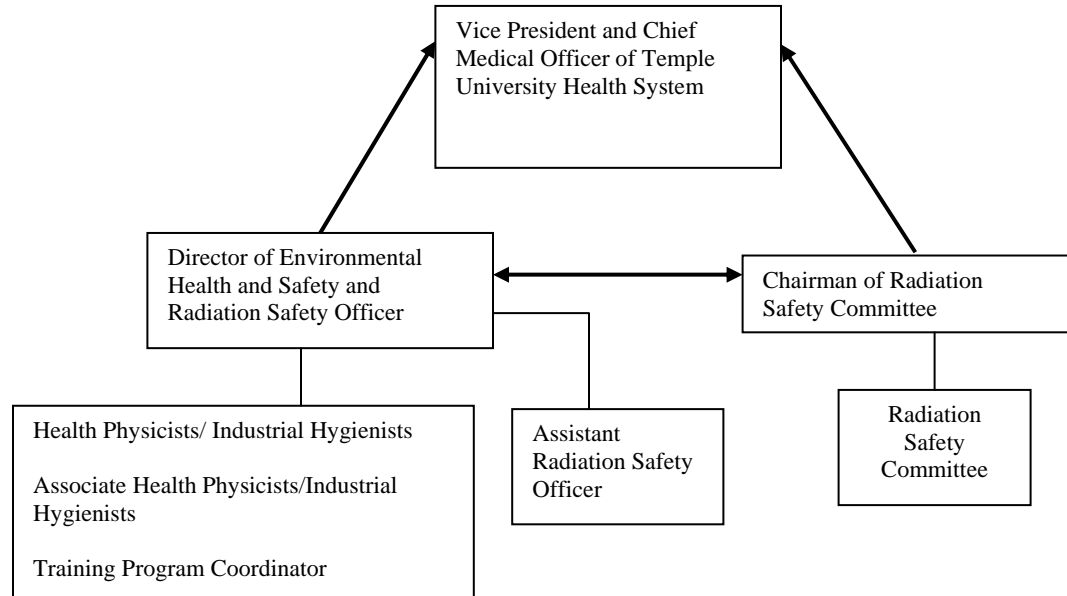


# RADIATION SAFETY PROGRAM

## A. *Individuals Responsible for Radiation Safety Program*

The Vice President and Chief Medical Officer of Temple University Health System is responsible for oversight of Temple University’s Radiation Safety Program and has the ultimate responsibility for the license and the activities associated with the PA licenses. He has appointed a Radiation Safety Officer (RSO) who is responsible for the implementation of the Radiation Safety Program. He has also established a Radiation Safety Committee (RSC) to oversee the activities authorized by the licenses. The membership of RSC is appointed by the Vice President and Chief Medical Officer and includes senior managers (Directors, Chairpersons, Heads) of those departments/divisions that are involved in the use of radioactive material or radiation producing equipment to assure active participation of members of senior management in the implementation of the Radiation Safety Program.

## B. *Organization Chart*



## C. *Radiation Safety Committee (RSC)*

The RSC oversees the conduct of activities authorized by the PA licenses. The RSC discharges its responsibilities through the Radiation Safety Officer (RSO).

The Duties and Responsibilities of the Radiation Safety Committee

The RSC is responsible for:

- Assisting the Executive Vice President in the management of the radiation safety program
- Ensuring, with the assistance of the RSO, that radiation safety program receives an appropriate level of support and resources

- Ensuring that all radioactive materials and radiation-producing equipment are used in compliance with all regulatory requirements and institutional policies and procedures
- Ensuring that the use of radioactive material and radiation-producing equipment is used consistent with the ALARA philosophy and program. Reviewing the training and experience of the proposed authorized users, radiation safety officer, teletherapy and medical physicists, to assure that they meet the regulatory requirements and assess whether qualifications are sufficient to enable the individuals to perform their duties safely
- Reviewing and approving or disapproving, with the advice and consent of the RSO and the representative of the management, all radiation safety procedures and changes in the radiation safety program
- Establishing the investigational levels for individual occupational radiation exposures
- Identifying the radiation safety program problems and providing solutions to these problems
- Reviewing all requests for authorization to use radioactive material on the basis of need, safety and the ALARA philosophy; and approve or disapprove the requests with the concurrence of the RSO
- Periodically reviewing the RSO's summary report of the occupational radiation exposure records of personnel, paying particular attention to individuals or groups of workers whose occupational exposures appear excessive
- Reviewing annually, with the assistance of the RSO, the radiation safety program
- Recommending remedial action to correct any deficiencies identified in the radiation safety program audits

#### ***D. Radiation Safety Officer (RSO)***

The management has assigned the RSO the responsibility to ensure that all licensed activities are conducted in accordance with the current regulatory requirements. The RSO is given the authority to stop an operation immediately if, in her judgment, the operation is unsafe or is in violation of Temple University policies. Furthermore, the RSO may require specific actions by the users to assure compliance with Temple University policies, and Federal and State regulations.

#### **RESPONSIBILITIES OF RSO**

The RSO is responsible for:

- general surveillance of all radiation safety activities, including investigation of overexposures, accidents, spills, losses, thefts, unauthorized receipts, uses, transfers, disposals, misadministrations, and other deviations from approved radiation safety procedures, and implementation of corrective actions
- developing and implementing an audit program to verify compliance by the users, with regulatory requirements and Temple University's policies
- developing and implementing radiation safety training program for workers
- developing and implementing a personnel monitoring program for workers, including the need for bioassays, reviewing of personnel exposure records, and developing corrective actions for those exposures approaching the regulatory limits
- performing a preliminary review of all proposed uses of radioactive material and making appropriate recommendations to the RSC for final approval or disapproval

- performing an initial review of requests for new authorizations/procedures and making appropriate recommendations to the RSC for final approval or disapproval
- reviewing and approving the request for the ministerial changes in the use of radioactive material
- controlling the procurement of radioactive material, including the authorization of purchase of radioactive material
- establishing and implementing procedures for receiving and opening packages of radioactive material
- packaging, labeling, surveys, etc., of all shipments of byproduct material
- performing leak tests and inventories of sealed sources
- evaluating relevant equipment, physical facilities, operational techniques and procedures and assigning personnel to perform those tasks
- managing the radioactive waste program including collection, storage and disposal of radioactive waste
- monitoring the Quality Management Program (QMP)
- performing or directing the decontamination activities
- preparing an annual report on the radiation safety program for a review by the RSC and the management
- participating in the activities of the Medical Radiation Subcommittee, Institutional Review Board and Radioactive Drug Research Committee as an active and voting member of these committees
- maintaining records required by the regulations

***E. Authorized Users (AU)***

Authorized Users are faculty members are approved by the Radiation Safety Committee to use radioactive materials under specific conditions. An AU is approved to possess and use specific radioisotopes for the amount and the use as described in the authorization application (appendix D).

**RESPONSIBILITIES OF AU**

Authorized User is responsible for:

- ensuring safe use of radioactive material under their respective controls
- the health and safety of anyone using or affected by the use of radioactive materials under his or her direction or supervision.
- ensuring that personnel working under their supervision receive appropriate radiation safety training prior to using radioactive material, including work-specific training
- notifying EHS in writing and receiving approval prior to any changes in the approved procedures, addition and deletion of laboratories and deactivation.
- providing necessary equipment and supplies for safe use of radioactive materials
- performance of the required periodic surveys
- security of radioactive materials, and radioactive wastes
- maintenance of inventory of radioactive material in their possession

- ensuring that his/her employees, staff and visitors comply with relevant regulations, policies and procedures.
- attending the initial radiation safety training and annual refresher training offered by EHS.
- ensuring that personnel working under their supervision are appropriately monitored.

#### ***F. Radiation Workers***

Individuals who use radioactive materials or radiation-producing machines under the supervision of one or more authorized user(s) are radiation workers.

#### **RESPONSIBILITIES OF RADIATION WORKERS**

Radiation worker is responsible to:

- attend an initial radiation safety training class and annual refresher radiation safety training offered by EHS.
- be familiar with the isotopes in use; know their radiological, physical and chemical properties, methods of detection, the types of hazards presented by each one, and the specific precautions and handling requirements for each isotope.
- be familiar with all the relevant procedures of the radiation safety program, RAM order, receiving and radioactive waste disposal procedures.
- know the proper use of appropriate radiation survey instruments.
- know how to wear, handle and store the radiation monitoring badges and return the badges promptly at the end wear period as specified by EHS.
- maintain appropriate inventory, disposal and survey records.
- secure radioactive materials by making sure that radioactive materials are locked away or are under immediate supervision within the laboratory.
- inform coworkers and visitors to the work area about the presence of radioactive materials and of any precautions they should take.
- know who to call in any incident involving sources of radiation and how to handle spills and personal contamination.

#### ***G. Radioactive Drug Research Committee (RDRC)***

The Food and Drug Administration (FDA) mandates that all research studies that involve the use of radioactive material in or on humans, be reviewed and approved by the RDRC. The RDRC will review all research protocols that involve the use of radioactive material in or on human subjects regardless of the amount of radioactivity. The RDRC only approves research studies that are intended to obtain basic information regarding the metabolism (including kinetics, distribution, and localization) of radioactive labeled drugs or regarding human physiology, pathophysiology, or biochemistry. The RDRC would not review and approve studies that are intended for immediate therapeutic, diagnostic, or similar purposes or to determine the safety and effectiveness of the drug in humans for such purposes (i.e., to carry out a clinical trial). Approval of the RDRC, the RSC and the Institutional Review Board (IRB) are required prior to initiation of any research on human by the use of radioactive drugs.

The RDRC will review and approve a research protocol, if it considers that scientific knowledge and benefits are likely to result from such study. Therefore, a protocol should be based upon a sound rationale derived from appropriate animal studies or published literature and must be designed such that information of scientific value may result. The radiation dose should be minimized and should be no greater than is necessary to obtain valid measurement. The projected number of human subjects should be sufficient but no greater than is necessary for the purpose of the study.

The RDRC submits an annual report on or before January 31 of each year to the FDA. The annual report includes the names and qualifications of the members of, and of any consultants used by, the RDRC, for each study conducted during the preceding year. The RDRC activities are monitored and reviewed periodically by the FDA. The FDA may monitor by reviewing the RDRC annual reports, by reviewing full protocols for certain studies, and/or by on-site inspections.

### **Charge of RDRC**

The RDRC requires that:

- The investigator be qualified by training and experience to conduct the proposed research studies.
- The responsible investigator be an authorized user approved by the RSC in use of the specific radionuclides.
- The investigator selects the appropriate human subjects and submits the protocol to obtain a review and approval of IRB.
- The investigator obtains the consent of the human subjects or their legal representatives. (The research subjects are at least 18 years of age and legally competent. Exceptions are permitted only in those special situations when it can be demonstrated to the committee that the study presents a unique opportunity to gain information not currently available, requires the use of research subjects less than 18 years of age, and is without significant risk to the subject).
- The investigator obtains a written statement from each female research subject of potential childbearing age that she is not pregnant, or, on the basis of a pregnancy test, is confirmed as not pregnant, before she may participate in any study.
- The investigator provides absorbed dose calculations based on biologic distribution data available from published literature or from other valid studies.
- The investigator provides an acceptable method of radioassay of the radioactive drug prior to its use to assure that the dose calculations actually reflect the administered dose.
- The investigator utilizes adequate and appropriate instrumentation for the detection and measurement of the specific radionuclide.
- The radioactive drug chosen for the study has a combination of half-life, types of radiations, radiation energy, metabolism, chemical properties, etc., that result in:
  1. The smallest radiation dose to whole body or specific organs of subject, which is practical to perform the study without jeopardizing the benefits that are to be obtained from the study.
  2. The radiation dose to an adult research subject from a single study or cumulatively from a number of studies conducted within 1 year does not exceed the following:

Research Subject	Single dose rem	Annual and total dose commitment Rem
<b>Adult</b>		
Whole body, active blood-forming organs, lens of the eye, and gonads	3	5
Other organs	5	15
<b>Minor under age of 18</b>		
Whole body, active blood-forming organs, lens of the eye, and gonads	0.3	0.5
Other organs	0.5	1.5

3. All radioactive materials included in the drug either as essential material or as a significant contaminant or impurity are included in determining the total radiation doses and dose commitments. Radiation doses from x-ray procedures that are part of the research study (i.e., would not have occurred but for the study) are also included.
  4. The possibility of follow-up studies shall be considered for inclusion in the dose calculations.
  5. Numerical definitions of dose should be based on an absorbed fraction method of radiation absorbed dose calculation, such as the system set forth by the Medical Internal Radiation Dose Committee of the Society of Nuclear Medicine, or the system set forth by the International Commission on Radiological Protection.
- The investigator should provide pharmacological dose calculations based on data available from published literature or from other valid human studies. The pharmacological dosage that the amount of active ingredient or combination of active ingredient should not be known to cause any clinically detectable pharmacological effect in humans, and the total amount of active ingredient without radionuclide shall be known not to exceed the dose limitations.
  - The radioactive drug used in the research study should meet the appropriate chemical, pharmaceutical, radiochemical, and radionuclide standards of identity, strength, quality, and purity as needed for safety and be of such uniform and reproducible quality as to give significance to the research study conducted. The investigator must assure the committee that the radioactive drugs are prepared in sterile and pyrogen-free forms for the parenteral use.
  - The investigator must immediately reports all adverse effects associated with the use of the radioactive drug in the research study. All major adverse reactions probably attributable to the use of the radioactive drug in the research study must be immediately reported by the RDRC to the FDA

The RDRC reviews the protocols for the following:

1. The radiation exposure is justified by the quality of the study being undertaken and the importance of the information it seeks to obtain;
2. The safe use of radioactive material in humans related to good Radiation Safety Practices;
3. The qualification and experience of the principle investigators and co-investigators in performing the radiation study in humans;

4. The consent forms;
5. The adverse reactions, and considers the adverse reactions related to radiation use and the statement related to the radiation exposure;
6. selection and consent of research subjects and
7. research protocol design.

#### ***H. The Medical Radiation Subcommittee (MRC)***

The subcommittee (MRC) serves as an advisory body to the Temple University Radiation Safety Committee (RSC) in the use of ionizing and non-ionizing radiation in or on humans. The RSC appoints the members and chairperson of the MRC.

#### **Administrative Requirements of MRC**

- The membership of the MRC will include the Radiation Safety Officer (RSO) and individuals with expertise in the fields that the RSC considers to be appropriate.
- The Committee will meet as often as necessary.
- One-half of the members, including the RSO or her designee, will constitute the quorum.

#### **Charge of MRC**

The Medical Radiation subCommittee will:

- Evaluate all proposals for research, diagnostic, and therapeutic use of radioisotopes and radiation producing (ionizing and non-ionizing) devices anywhere within Temple University involving application or administration of radiation or radioactive materials to humans;
- Evaluate the qualifications and experience of the principle investigators and co-investigators performing the radiation studies on humans;
- Evaluate the radiation doses to humans and safe use of radioactive materials and radiation-producing equipment related to good radiation safety practices;
- Ensure that the radiation exposure to humans from the use of radioactive materials and radiation-producing equipment is consistent with the ALARA philosophy;
- Evaluate the radiation exposure, the quality of the study being undertaken, and the importance of the information it seeks to obtain;
- Review and make recommendations for the research consent forms. Review and consider the adverse reactions related to radiation use and the statement related to the radiation exposure;
- Review and consider the number of research subjects to be enrolled in the proposals;
- Make recommendation to RSC to approve or disapprove the proposals.
- The RSC will notify the Institutional Review Board (IRB) in writing regarding the status of the approved protocols for the IRB's final approval.

# Radiation Safety Procedure

## A. *Training Program*

The Environmental Health & Safety (EHS) Department provides radiation safety training to workers. Basic radiation safety training is provided to all new workers. All individuals who plan to use or work with radioactive material must complete the radiation safety training. EHS provides this initial training to all new radiation workers. Several sessions of this training are held throughout the year. The authorized user provides initial training to a new radiation worker until the next session of training by the EHS.

The training needs of individuals vary based on the individual's responsibilities and the risk of exposure. Therefore, the training requirements are specifically tailored based on the individual's work activities associated with radioactive material. Additional radiation safety training, including any changes in procedures, specific to the duties of an individual is provided by the authorized user under whose supervision the individuals may work.

The effectiveness of the training program and the competency of the workers are evaluated during the periodic audits by the EHS. The RSO reviews the results of these evaluations and may recommend to the RSC modifications or changes in the contents, or methods of providing the training in order to address any weakness in the training program. These changes in the training program are reviewed and approved by the RSC prior to implementation.

### 1. **Initial Radiation Safety Training**

Some or all of the following topics may be included in the initial training. The details of these topics are commensurate with an individual's anticipated work and the risks associated with his/her use of radioactive material.

- Radioactivity and radioactive decay
- Sources of ionizing radiation
- Interaction of radiation with matter
- Radiation detection and measurement
- Biological effects of ionizing radiation
- Radioactivity measurements, monitoring techniques, and use of radiation detection instruments
- Mathematics and basic calculations to using and measuring radioactivity
- Principles and practices of radiation protection
- An overview of the environmental health and safety at Temple University
- Description of the concept of ALARA and its application
- Description of dose limits, signs and other legally mandated requirements
- Conditions of Temple University licenses and their application
- Other subjects related to radiation protection standards



Additional practical training is provided to certain individuals that may include the following:

- Contamination and decontamination;
- Proper use of survey instruments;
- Proper methods to perform survey;
- Practical aspects of working with radioactive materials, and
- Other subjects that in the opinion of the RSO and/or the RSC would be beneficial to the individuals

New radioactive material users who have received radiation safety training elsewhere are required to receive training in the following topics:

- An overview of the environmental health and safety at Temple University
- The concept of ALARA and its application
- Dose limits, caution signs and other regulatory requirements
- Conditions of Temple University licenses

## **2. Annual Refresher Training**

EHS provides annual refresher training to all radiation workers. All radiation workers must attend this training in order to remain an active radiation worker. This training includes a review of new policies and regulations.

## **3. Radiation Safety Training for Clinical Staff**

This annual training is provided to users of radioactive materials and/or radiation producing machines.

## **4. Radiation Safety Training for House Keeping, Physical Plant and Security Staff**

This annual training is for individuals who frequently enter areas where radioactive materials are used or stored.

## **5. Radiation Safety Training for Irradiator Workers**

Individuals who work with an irradiator are required to have the radiation safety training for the irradiator prior to work with the irradiator.

## ***B. Audit Program***

EHS performs periodic audits of area of use and storage of radioactive materials. The audit assesses if the authorized activities are being conducted in a safe manner and in accordance with regulatory requirements and Temple University Policies. The audit reviews the adequacy of facilities for the type of use, training of workers, supervision by authorized user(s), availability of survey instruments, security of radioactive material, minimization of personnel exposure to radiation, and the required record keeping.

The authorized user is informed if any deficiencies are noted. The RSO issues a notice of violation to the authorized user if a violation of regulatory requirement or license conditions is identified and the RSO determines that the violation has safety significance. The authorized user is required to respond to the notice. The results of the audit are presented to the RSC. Details of significant violations are discussed by the RSC. The RSO has the authority to limit authorized user's use of radioactive material or in extreme cases suspend the use of radioactive material if the violations persist or are not addressed adequately.

### ***C. Survey Program***

Radiation surveys are performed to identify and quantify radiation exposure situations, and to provide the basis for remedial actions to reduce exposure to as low as reasonably achievable (ALARA). Release of radioactivity to the environment also needs to be controlled and monitored to ensure compliance with regulatory requirements. Control of contamination is through the effective use of protective coverings of work surfaces, containment of radioactivity during processes, personal protective clothing, and careful attention to avoid spills. A primary element of such a program is monitoring for contamination by appropriate surveys.

The instruments used in these surveys should be suited for the type of measurement, energy, and source of radiation. A survey using an instrument such as a Geiger-Mueller counter is acceptable as long as it is sensitive enough to detect the nuclides used. A survey instrument equipped with a low energy sodium iodide crystal should be used for detecting iodine 125. For low energy beta emitters such as H-3, C-14, S-35 or P-33, contamination surveys should be conducted using swipes (or smear wipes), which are counted using a liquid scintillation counter. An appropriate and effective filtering system should be in place while using a volatile radioactive material, such as iodine 125.

The authorized users are required to perform appropriate surveys at the end of the day on the days radioactive material is used. These surveys are meant to detect any contamination in areas of use or the equipment. If any contamination is detected during these surveys, the user are required to decontaminate the area before leaving the area. If a complete decontamination can not be accomplished, the user must cover the contaminated area or the equipment and mark it with caution labels to prevent spread of contamination to other areas. The authorized user are required to perform periodic contamination surveys of those areas where radioactive materials are stored and/or used. Any area found to be contaminated must be decontaminated as soon as practical. Periodic surveys should include surveys for detection and removal of contamination. The authorized user must maintain records of these periodic surveys. EHS reviews these records during its periodic audit of the laboratories.

The frequency of these surveys depends upon the amount, type and frequency of use. Therefore, a classification of laboratories where radionuclides are used is necessary to determine how frequently they should be surveyed. Three levels of survey frequencies are designated based on the nature of the radionuclide, its activity, and its use. The concept relies upon the principle that certain radionuclides are more hazardous than others, and thus require more frequent monitoring. Furthermore, each application is associated with certain risks, so the nature of operation dictates the frequency of monitoring. Finally, use of larger quantities of a radionuclide necessitates more frequent monitoring. Table 3 is developed based on these principles and specifies the frequencies of monitoring in various laboratories.

TABLE 1. CLASSIFICATION OF RADIONUCLIDES  
ACCORDING TO RELATIVE RADIOTOXICITY

GROUP I

Pb-210	Po-210	Ra-226	Ac-227	Th-227	Th-228
Th-230	Pa-231	U-230	U-232	U-233	U-234
Np-237	Pu-238	Pu-239	Pu-240	Pu-241	Am-241
Am-243	Cm-242	Cm-234	Cm-244	Cm-245	Cm-246

GROUP II

Na-22	Cl-36	Ca-45	Sc-46	Mn-54	Co-60
Sr-89	Sr-90	Y-91	Zr-95	Ru-105	Ag-110m
Cd-115m	In-114m	Sb-124	Sb-125	Te-127m	Tc-129m
I-123	I-125	I-126	I-129	I-131	Cs-134
Cs-137	Ba-140	Ce-144	Tb-160	Tm-170	Hf-181
Ta-182	Ir-192	Ti-204	Bi-207	Bi-210	At-211
Pb-212	Ra-224	Ac-228	Pa-230	Th-234	U-236

GROUP III

H-3	C-14	F-18	Na-24	P-32	P-33
S-35	K-42	K-43	Ca-47	Sc-47	Cr-51
Mn-52	Fe-55	Fe-59	Co-57	Co-58	Bi-63
Ni-65	Zn-65	Ga-72	As-73	As-74	As-76
As-77	Se-75	Br-82	Kr-85m	Rb-86	Sr-85
Kr-87	Y-90	Nb-95	Mo-99	Tc-97	Tc-99
Ru-97	Ru-103	Rh-105	Pd-109	Ag-105	Ag-111
Cd-109	Sn-113	Rh-105	Sb-122	Te-129	Te-131m
Te-132	Xe-127	Ba-131	La-140	Ce-141	Ce-143
Pr-143	Nd-147	Nd-149	Pm-147	Pm-149	Sm-151
Sm-153	Eu-155	Cd-159	Dy-165	Ho-166	Fr-169
Er-171	Tm-171	Yb-175	La-177	Re-186	Ir-190
Ir-194	Pt-191	Pu-197	Pt-197	Au-196	Au-198
Hg-197	Hg-197m	Hg-203	Ti-201	Ti-202	Pb-203
Rn-222	Th-231				

GROUP IV

O-15	A-37	Co-58m	Ni-59	Zn-69	Ge-71
Kr-85	Sr-85m	Rb-87	Y-91m	Zr-93	Nb-97
Tc-96m	Tc-99m	Rh-103m	In-113	Xe-131m	Xe-133
Cs-134m	Cs-135	Sm-147	Re-187	Os-191m	Pt-193m
Pt-197m	Th-232	U-235	U-238	U-Nat	

Group 1 is the most radiotoxic and Group IV is the least

TABLE 2. HANDLING FACTORS

<u>Operation</u>	<u>Handling Factor</u>
HF(0.1) <sup>a</sup>	0.1
HF(1) <sup>b</sup>	1
HF(10) <sup>c</sup>	10

- a. HF(0.1) consists of infrequent operations or those requiring uCi quantities of radionuclides.
- b. Routine laboratory procedures requiring mCi quantities of radionuclides.
- c. Operations requiring complex procedures or those involving volatile radionuclides.

Examples:

<u>Operation</u>	<u>Activity</u>
HF(0.1)	storage
HF(0.1)	sample counting
HF(0.1)	radioimmunoassay
HF(1)	uptake studies
HF(1)	metabolic studies
HF(10)	radioiodinations
HF(10)	<sup>3</sup> H exchange labeling

TABLE 3.

FREQUENCY OF DOCUMENTED SURVEY FOR CERTAIN RADIONUCLIDES BASED ON THEIR ADJUSTED QUANTITY IN mCi-eq

	Monthly	Weekly	Daily
Group I	<0.01	0.01 to 1	>1
Group II	<1.0	1.0 to 10	>10
Group III	<10.0	10 to 100	>100
Group IV	<100.0	100 to 1000	>1000

### 1. Survey for Removable Contamination

The smears, or wipe tests, are used for surface contamination monitoring. Counting for beta radiation is done with a liquid scintillation counter (LSC). Gamma contamination on wipes can be measured with a liquid scintillation or gamma counter. All areas or equipment must be cleaned to ensure that removable contamination is below 200 dpm/100 cm<sup>2</sup>. A dry smear taken from an area of about 100 cm<sup>2</sup> is acceptable to indicate levels of removable contamination.

The activity in dpm is determined by dividing the net counts per minute (gross counts - background) by the detection efficiency of the instrument being used.

$$\text{disintegrations per min (dpm)} = \text{net count rate (cpm)} / \text{counter efficiency}$$

## 2. Radiation Exposure Survey

A proper type of survey instrument should be chosen, and measurements made at all points where exposure may occur. If the exposure is at the contact point, then the measurement point should be at the contact point. Conversely, if the exposure is at about 1 meter from the source, then the measurement point should be at 1 meter. The minimum limit of detection of the survey instrument should be 0.1 mrem/hr.

### *D. Waste Management*

EHS is responsible for the management and disposal of all radioactive waste that is generated at various sites. Radioactive waste is segregated and handled according to its characteristics. All radioactive waste is disposed of either by decay-in-storage, via public sewer system, or by transfer to an authorized recipient for burial or incineration in accordance with all current regulatory requirements.

EHS provides appropriate radioactive waste containers to the users of radioactive material for storage of radioactive waste. The users are responsible to segregate radioactive waste according to half-life of the isotope present in the waste, and store it in the appropriately labeled container. The users are required to remove "radioactive" labels or deface them prior to depositing in the containers. Liquid waste is similarly stored in separate containers. EHS staff verifies compliance with these procedures during the periodic audits. Generation of mixed waste (radioactive plus any other hazardous material) is discouraged mainly because of the high cost of its disposal. Biological and pathogenic wastes except for animal carcasses are treated to reduce the infectious nature of the waste. The short half-life wastes are held for decay and then are disposed of as non-radioactive waste. Long half-life wastes are shipped to a licensed facility. House keeping staff is not authorized to collect radioactive waste in order to eliminate the possibility of unauthorized disposal. Appropriate training is provided to the house keeping staff.

### *E. Visitors*

The Temple University Radiation Safety Committee has implemented safety policy regarding entering laboratories designated for radioactive material use and/or storage. The policy is as follows:

Any individual who has not received radiation safety training commensurate with the potential radiological hazard present and is not under the direct and constant supervision of the Authorized User is **prohibited** from entering laboratories designated for radioactive material usage and/or storage.

Minors (persons under the age of 18 years old) are also **prohibited** from entering these labs unless special arrangements including training provided by the Radiation Safety Department, are made with the Radiation Safety Officer and/or the Radiation Safety Committee prior to entry.

### *F. Safety Devices*

Authorized Users must notify the EHS prior to initiation of significant modifications to areas where radioactive materials are approved for use. The proposed modifications must be approved by RSO.

#### 1. General Requirement

Each laboratory that uses radioactive material should have:

- Drip trays and /or absorbent paper for contamination control

- Appropriate means to respond to emergency and decontamination activities
- labeled containers for collection of radioactive waste materials

## 2. Additional Requirement for Gamma Emitter Isotopes

The laboratories that use more than 1 mCi of low energy gamma ( $E < 100$  keV), or more than 100 uCi of high energy gamma ( $E > 100$  keV) radioisotope should have:

- Lead or other high-density materials for bench use and storage.
- Remote handling tools, such as forceps, tongs, or extension handles.

## 3. Additional Requirement for High Energy Beta Emitter Isotopes

The laboratories that use more than 2 mCi of beta emitting isotopes of energy exceeding 1 MeV should have:

- Low atomic number materials such as high-density plastics for bench use and storage.
- Remote handling tools, such as forceps, tongs, or extension handles.

## 4. Lockable Storage Equipment

Lockable storage equipment is required for laboratories with possession limits that exceed the values listed in table below.

Isotopes	mCi
Calcium-45	100
Carbon-14	100
Cesium-137	10
Chlorine-36	10
Chromium-51	1000
Cobalt-57	100
Cobalt-60	1
Hydrogen-3	1000
Indium-111	100
Iodine-123	100
Iodine-125	1
Iodine-131	1
Manganese-54	100
Molybdenum-99	100
Nickel-63	100
Phosphorus-32	10
Phosphorus-33	100
Plutonium-239	0.001
Potassium-40	100
Sulfur-35	100
Technetium-99m	1000
Thallium-201	1000
Thorium-232	100
Xe-133	1000

Call EHS for other isotopes.

#### **5. Requirement for Iodination Procedure**

All laboratories where iodination procedures are performed should have chemical-type fume hood and, or glove box, or similar equipment with sampling systems that provide for continuous monitoring of effluent release.

#### **6. Requirement for Process that Produces Particulates or Aerosols**

All laboratories where grinding or any other process where radioactive particulates or aerosols may be generated, should have chemical-type fume hood, and or glove box and or similar equipment.

### ***G. Material Receipt and Accountability***

All radioactive material is ordered through EHS. Users are required to obtain authorization from EHS prior to ordering any radioactive material. EHS authorizes procurement of the material after verifying that the user is authorized to receive the material, the requested amount is within his/her authorized possession limit, and the additional material plus the material already in the user's possession does not exceed the user's possession limit.

All radioactive material is received by EHS. The EHS staff opens the packages after performing the required radiological surveys. The contents are verified by comparing the order and the packing slip accompanying the package. The material, the amount, and the name of the user are recorded in the computerized material inventory maintained by EHS. Each package is assigned an inventory identification number before it is delivered to the intended user by EHS. Authorized users are required to maintain a running inventory of the materials in their possession.

#### **1. Transfer of Radioactive Materials between Authorized Users**

An authorized user may transfer radioactive material in his/her possession to another user provided such a transfer is approved by the EHS. Approval for such transfer is granted by EHS after verifying that the recipient is authorized to possess the material and additional material does not exceed his/her possession limit. The inventory records maintained by EHS are updated accordingly.

#### **2. Transfer of Radioactive Material to Another Institution**

Transfer of radioactive material to another user outside of Temple University is not allowed without prior approval of EHS. The user must submit the amount and the name of material along with the name of RSO of the receiving institution. Authorization for the transfer is granted after verification by EHS that the intended receiver is authorized to possess the material that is being transferred. The material being transferred must be delivered to EHS for packaging. The EHS staff prepares the package for shipment in accordance with the regulatory requirements. The package is shipped by EHS to the intended institution and the inventory record is updated accordingly.

## ***H. Security of Radioactive Material***

All radioactive material must be stored in such a way that prevents access by unauthorized individuals. All authorized users are responsible to secure all radioactive material in their possession. Security of radioactive material is reviewed during the periodic audits by EHS.

### ***I. Inventory of Sealed Sources***

Any radioactive material encased in a capsule designed to prevent leakage or escape of the radioactive material is defined as a sealed source. It is imperative that all radioactive sealed sources are properly accounted for and the periodic inventories are performed.

#### **1. Registration of Sources**

All sources of radioactive material sealed or encapsulated is registered with EHS

#### **2. Inventory Control**

The physical inventory of all sealed sources used in research are performed semiannually. The inventory consists of the model; serial number, if any; location (room, building) of the source; and initials of the individual who performed the inventory.

#### **3. Leak Test of Sealed Sources**

All sealed sources containing 100 uCi or more of beta or gamma emitting radionuclides or 10 uCi or more of alpha-emitting material in any form other than gas will be tested for leakage and contamination by EHS, every six months. Exceptions are as follows:

- sources containing exclusively hydrogen-3.
- sources containing radionuclides with a half-life of less than 30 days.
- Iridium-192 seeds in nylon ribbon.
- Sealed sources that are in storage. Sealed sources not in use and identified as stored will be leak tested before any use or transfer. Stored sources will be leak tested every ten years.

### ***J. Notification***

Report any issues concerning radiation, unsafe practices or any violations of regulatory requirements to the attention of the Radiation Safety Officer. Radiation safety officer must be notified immediately in the event of

- Loss of radioactive materials, devices that contain radioactive materials or any sealed/checked sources.
- Any incident that caused released of radioactivity to the environment
- Any condition which may lead to or cause a violation
- Acquisition, transfer or disposal of equipment that contain radioactive materials
- Personnel contamination
- Any accident resulting in direct exposure to personnel



- Major spill
- Spill with removable contamination above the trigger level

## ***K. Safety Instructions***

### **1. Safe Use of Radioactive Material and Emergency Procedures**

Each laboratory or area where radioactive material is used or stored should follow these general safety rules:

- Wear a laboratory coat or other protective clothing at all times in areas where radioactive materials are used
- Wear disposable gloves at all times when handling radioactive materials
- After each procedure or before leaving the area, monitor hands, shoes, and clothing for contamination in a low background area
- Do not eat, drink or smoke in any room where radioactive materials are used or stored
- Do not store food, drink or personal effects in areas where radioactive material is stored or used
- Never pipette by mouth
- Wear personnel monitoring devices, if required, at all times while using radioactive materials
- Dispose of radioactive waste only in designated, labeled and properly shielded waste receptacles
- Store radioactive solutions in clearly labeled containers
- Do not leave radioactive materials and wastes unsecured in an unattended lab, even for a short time, unless the lab is locked
- Work in a hood during procedures using volatile materials such as unlabeled I-125, I-131 or millicurie amounts of S-35 methionine/cysteine
- Survey yourself and your clothing when radioisotope work is finished and before leaving the lab

### **2. Additional Safety Instruction in Use of Phosphorus-32**

Individuals, who order and use over 2 mCi of phosphorus-32, should follow these additional safety precautions:

- Use a low-density plastic (Plexiglas) shielding to protect yourself from the bremsstrahlung radiation
- Keep the stock vial of P-32 in a shield when not in use
- Wear body and ring badge for procedures that involve over two millicuries of P-32
- Run a dry run before start of unfamiliar procedures, in order to preclude unexpected complications
- Protect your eye (glass or goggle) for procedures that involve over 10 millicuries of P-32
- Keep radioactive waste in separate shielded containers
- Survey the area(s) of use after the use

### **3. Additional Safety Instruction for I-125, I-131 Iodination**

Individuals who perform iodination procedures should follow these additional safety precautions must be followed:

- Iodination, including primary purification, should be performed in an operating fume hood with effluent monitoring unless other specific arrangements have been approved by RSO
- Approval from RSO must be obtained before the first iodination procedure
- An appropriate survey instrument should be available during the entire procedure
- Check hood operation before initiating the procedure
- Do not proceed if the hood is not functioning and notify EHS immediately
- Wear your dosimeter
- Do a dry run prior to performing any unfamiliar procedure, in order to preclude unexpected complications
- Use tongs or similar tools for handling the stock vial of radioiodine, mixing (reaction) vessel and other containers (such as fraction collection tubes, column purification and stock labeled material container)
- All waste generated from this procedure must be placed under the hood in plastic bags, sealed and labeled
- After completion of the iodination procedure perform a radiation survey and wipe test for radioactive contamination
- Perform complete personal survey (hands, lab coat and sole of shoes) after each iodination procedure with appropriate survey instrument at low background area
- Arrange with EHS for bioassay procedure. Individuals who do not submit to bioassay will be referred to RSC for disciplinary action

### **4. Potential Releases of Radioactive Materials to Unrestricted Areas**

Notify EHS immediately if an emergency occurs during the use of radioactive materials that could result in a release of material to unrestricted areas of buildings, or a release of radioactive materials to the environment. Such an event requires collection of certain data to determine the potential impact of the release on employees, members of the public and property. The nuclide(s) involved, along with the activities, should be known and communicated to the EHS. Also, the nature of the event which could have led to the release should be described (i.e. containment failure, hood failure, etc.), along with the time and duration of the event.

### **5. Minor Spills of Liquids and Solids**

Follow the following precautions if a minor spill of radioactive material occurs:

- Place absorbent material over the spill to keep it from spreading
- Notify others in the area, and limit access to the spill area
- Monitor yourself and others for contamination and decontaminate immediately if you find any contamination
- Survey the suspected area to determine the boundary of the contaminated area and label with

"Caution Radioactive Material" tape

- Gather cleaning supplies such as moistened paper towels and scouring powder or any detergent
- Do not ask housekeeping staff to assist in the cleanup or to lend you their equipment
- Wear protective clothing, i.e., lab coat and gloves (and shoe covers if necessary) while decontaminating the spill area
- Minimize the volume of water used to decontaminate
- Begin cleaning at the edges of the spill and work towards the center (lowest to highest level of contamination)
- Dispose of all cleanup materials as radioactive waste
- Re-survey yourself for contamination, including the bottom of shoes, to prevent spread of contamination
- Smear the area to ensure that removable contamination is below the level stated in your laboratory survey form provided by EHS
- Document the spill cleanup on the laboratory survey form provided by EH
- Cooperate with the RSO and/or the EHS's staff in investigation of the cause. If requested provide bioassay samples
- Follow the instructions of the RSO and/or the EHS's staff in the decontamination techniques, surveys and documentation

## **6. Major Spills of Liquids and Solids**

Follow the following precautions when a major spill of radioactive material occurs:

- Clear the area. If appropriate, survey all persons not involved in the spill and vacate the room
- Prevent the spread of contamination by covering the spill with absorbent paper (paper should be dampened, if solids are spilled), but do not attempt to clean it up
- To prevent the spread of contamination, limit the movement of all personnel who may be contaminated
- Shield the source only if it can be done without further contamination or significant increase in radiation exposure
- Close the room and lock or otherwise secure the area to prevent entry. Post the room with a sign to warn anyone trying to enter that a spill of radioactive material has occurred
- Notify the EHS immediately
- Survey all personnel who could possibly have been contaminated. Decontaminate personnel by removing contaminated clothing and flushing contaminated skin with lukewarm water and then washing with a mild soap
- Allow no one to return to work in the area unless approved by the EHS
- Cooperate with the RSO and/or the EHS's staff in investigation of the cause. If requested provide bioassay samples
- Follow the instructions of the RSO and/or the EHS's staff in the decontamination techniques, surveys and documentation

## **7. Incidents Involving Radioactive Dusts, Mists, Fumes, Organic Vapors, and Gases**

- Notify all personnel to vacate the room immediately
- Shut down the ventilation system, if possible, unless it is determined that the room ventilation system needs to be used to clear the air for access purposes
- Vacate the room. Seal the area, if possible
- Notify the EHS immediately
- Ensure that all access doors to the area are closed and posted with radiation warning signs, or post guards (trained) at all access doors to prevent accidental opening of the doors or entry to the area
- Survey all persons who could have possibly been contaminated. Decontaminate as directed by the EHS
- Promptly report suspected inhalations and ingestion of radioactive material to the RSO
- Decontaminate the area only when advised and/or supervised by the EHS
- Allow no one to return to work in the area unless approved by the EHS
- Cooperate with the RSO and/or the EHS's staff in investigation of root and cause. If requested provide bioassay samples
- Follow the instructions of the RSO and/or the EHS's staff in the decontamination techniques, surveys and documentation

## **8. Contaminated Lab Coat, Clothing or Shoes**

Remove the contaminated item(s) and check the skin underneath for contamination. Place the item(s) in a plastic bag and label it with "Caution Radioactive Material" tape. Contact the EHS for assistance and instructions

## **9. Dose Assessment**

If it is reasonable and does not hinder the decontamination procedure, it is recommended that the radiation worker record the following data:

- Survey meter reading, type of meter, and distance between the survey probe and original reading of skin surface (if a survey meter was used to detect the contamination)
- Radionuclide and chemical compound involved
- Approximate amount of radioactivity involved
- Location on your body where the contamination occurred
- Dimensions of the area contaminated, i.e., square centimeters
- Length of time the radioactive material was on your skin or in your eye

## ***L. Emergency Response and Management***

Any unexpected event or accident situation that occurs during the transport, storage or use of radioactive materials constitutes a potential emergency. The EHS must be notified immediately when such an event results in contamination of work areas or personnel, or if significant quantities of radioactive materials are

released into the environment. Specific emergency procedures must be followed in such circumstances. It may also be required to notify the Temple University Police Department and the University Fire Marshal's Office depending upon the nature of emergency.

The EHS and the Radiation Safety Department is ready to provide emergency assistance any time of the day and any day of the week. You may call EHS or the Radiation Safety Department if you need assistance and information regarding management and/or use of radioactive materials and radiation producing equipment. For concerns about security or fire safety, you should call extension 1-1234 and state the nature of your concern and the specific assistance you seek.

Follow the following guidelines to obtain emergency help:

- During business hours (8:00am to 5:00pm on weekdays), contact EHS at (215) 707-2520, or call the page operator at (215) 707-4545 and ask the operator to page a representative of EHS.
- During other hours and on weekends and holidays, call the page operator at (215) 707 4545 and ask the operator to page a representative of EHS and if needed, the Fire Marshal's Office.
- University Security may also be contacted at 1-1234.

## **1. Fires**

The following procedure should be followed in case of fire:

- Sound the building fire alarm.
- Call extension 1-1234 and state the nature of the problem and location
- If possible, and trained to do so, attempt to put out the fire by approved methods (e.g., fire extinguisher) and only if other fire hazards or radiation hazards are not present
- Notify all persons present to vacate the area and immediately call the EHS
- Once the fire is out, isolate the area to prevent the spread of possible contamination
- Survey all persons involved in combating the fire for possible contamination
- Decontaminate personnel by removing contaminated clothing and flushing contaminated skin with lukewarm water, then washing with a mild soap
- In consultation with the EHS, determine a plan of decontamination and the types of protective devices and survey equipment that will be necessary to decontaminate the area
- Allow no one to return to work in the area unless approved by the RSO
- Cooperate with the RSO, Fire Marshal's Office, and/or the EHS's staff in the investigation of the root and causes. Provide bioassay samples if requested.
- Follow the instructions of the RSO and/or the EHS's staff in the decontamination techniques, surveys and documentation

## **2. Explosions/Fires, or Major Emergencies**

- Take the following steps in case of fire, explosion or any other such incident in the work area:
- Sound the building fire alarm.

- Notify all persons in the area to leave immediately
- Call extension 1-1234 and state the nature of the problem and location
- Notify the RSO
- Upon arrival of firefighters, inform them where radioactive materials are stored or where radioisotopes were being used; inform them of the present location of the radioactive materials and the best possible entrance route to the radiation area, as well as any precautions to avoid exposure or risk of creating radioactive contamination by use of high pressure water, etc.
- Cooperate with the RSO, Fire Marshal's Office, and/or the EHS's staff in the investigation of the root and cause. Provide bioassay samples if requested.
- Allow no one to return to work in the area unless approved by the RSO
- Follow the instructions of the RSO and/or the EHS's staff in the decontamination techniques, surveys and documentation

### **3. Injury with Personnel Contamination**

In the event of a serious injury (heavy bleeding, heart attack, etc.) seek medical assistance immediately. Notify your supervisor and the EHS. For a minor injury (e.g., puncture wound, suspected inhalation or ingestion of radioactive material, skin contamination, etc.), first attempt to decontaminate yourself before seeking medical assistance. Notify your supervisor and the EHS.

### **4. Contamination Only**

Skin contamination is always a possibility when working with radioactive materials and can result in significant radiation dose if not removed. It is important to detect skin contamination and decontaminate as quickly as possible. The dose to the skin from contamination must be assessed for inclusion in the individual's dosimetry record and to ensure adherence to applicable regulatory dose limits.

### Useful Information for the Radioisotope Most Commonly Used at Temple University

Isotope	Half life	Radiation type	Energy KeV	Intensity %	Dosimeter Yes/No	Range In air cm	Shielding Type	Detection instrument	Bioassay	Annual Limit Intake
<sup>3</sup> H	12.3 y	β <sup>-</sup>	18.6	100	No	0.47	NA	LSC	Urine bioassay for activity > 100 mCi	80 mCi
<sup>14</sup> C	5730 y	β <sup>-</sup>	156.5	100	No	22	NA	GM, LSC	Urine bioassay if intake or license condition	2 mCi
<sup>32</sup> P	14.3 d	β <sup>-</sup>	1710	100	>2 mCi	610	Plexiglas	GM, LSC	Urine bioassay if intake or license condition	600 uCi
<sup>33</sup> P	25.3 d	β <sup>-</sup>	249	100	no	45	NA	GM, LSC	Urine bioassay if intake or license condition	3 mCi
<sup>35</sup> S	87.4 d	β <sup>-</sup>	167	100	no	24	NA	GM, LSC	Urine bioassay if intake or license condition	6 mCi
<sup>45</sup> Ca	163	β <sup>-</sup>	257	100	no	48	NA	GM, LSC	Urine bioassay if intake or license condition	800 uCi
<sup>51</sup> Cr	27.7 d	γ	320	9.8	>100 uCi		Lead	GM, LSC, Gamma	Urine bioassay if intake or license condition	2 mCi
		Auger *	4.4	70						
<sup>125</sup> I	59.5 d	X-ray	3.8	15	>1 mCi		Lead	NaI GM, LSC, Gamma	Thyroid bioassay for activity >1 mCi	40 uCi
			27.2	40						
			27.5	74						
			31	26						
		γ	35.5	6.7						
		Auger *	3.19	156						
22.7	20									
ce**	3.7	79.8								
	30.6	10.7								
	34.5	2.1								
<sup>131</sup> I	8 d	β <sup>-</sup>	248-807	100	>100 uCi			NaI GM, LSC, Gamma	Thyroid bioassay for >1 mCi	30 uCi
			X-ray	29.5						
		29.8		2.5						
		γ	80.2	2.6						
			284.3	6.1						
			364.5	81.2						
			637	7.27						
		722	1.8							
Auger*	3.4	5.1								
ce**	329	1.5								

\*Auger electrons

\*\* Conversion electrons

## List of References

This guide was written using information provided in the following publications:

National Council on radiation Protection and Measurements, NCRP report No. 58. “A Handbook of Radioactivity measurements Procedures ”

National Council on radiation Protection and Measurements, NCRP report No. 127. “Operational Radiation Safety Program ”

United State Nuclear Regulatory Commission, NRC Technical Issues Papers TIP36, “Biological Effects of Radiation”

U.S. Nuclear Regulatory Commission, NUREG-1556, Vol.11, April 1999

U.S. Code of Federal Regulations, Title 10. Chapters 19, 20, 30, 33,35.



Appendix A  
Worker registration form



Appendix B.

**Application for Possession and  
Use of Radioactive Materials in Research**

**Applicant**

Name: \_\_\_\_\_ Degree: \_\_\_\_\_ Title: \_\_\_\_\_  
First MI Last MD, Ph.D., etc. Asst. Professor, Chairperson  
(must be a faculty position)

Department: \_\_\_\_\_ School: \_\_\_\_\_ Phone: \_\_\_\_\_

Campus address: \_\_\_\_\_

**Radioactive Material**

Radionuclide: \_\_\_\_\_ Chemical Form: \_\_\_\_\_

Physical Form: ( ) gas ( ) liquid ( ) sealed source ( ) other solid

for **sealed source**: manufacturer: \_\_\_\_\_ model #: \_\_\_\_\_

for **other solid**, describe source (e.g., powder, activated metal) \_\_\_\_\_

Activity per order: \_\_\_\_\_ ( ) uCi ( ) mCi ( ) Ci Order frequency: \_\_\_\_\_  
weekly, monthly, etc.

Activity per experiment: \_\_\_\_\_ ( ) uCi ( ) mCi ( ) Ci Experimental frequency: \_\_\_\_\_

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**Project Title and/or Objective**

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**RSD Use Only:**

Radionuclide: \_\_\_\_\_ Compound: \_\_\_\_\_ Possession Limit: \_\_\_\_\_ mCi

Radiation Safety Officer Approval: \_\_\_\_\_ Date: \_\_\_\_\_

RSC Approval: \_\_\_\_\_ Date: \_\_\_\_\_ Approval No.: \_\_\_\_\_

Approval Condition ( ) yes, see attached condition sheet ( )

## Project Description

Project duration:

Methods/Procedures: Provide step by step procedures for laboratory procedures performed with radioactive materials.  
(Additional pages/Reprints may be attached.)

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**Training:** List training (formal courses) pertinent to radiation safety

Type of training	Location/institution	Duration ( hours)
Principles of radiation protection		
Radioactivity measurement		
Physics & mathematics basic to use and measurement of radioactivity		
Biological effects of radiation		

**Experience:** List experience with radioactive materials

Radionuclide	Maximum activity used mCi	Institution	Duration of experience

Please note any special experience (e.g., iodination, phosphorylation, etc.)

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**Facilities**

Location: List the building(s) and room number(s) where radioactive materials will be used and stored, and the proposed use of the room, e.g., counting room, storage, and laboratory use.

Building	Room No.	List of equipment used with RAM fume hood*, glove box, centrifuge, etc.	Use

\*Please specify the type of fume hood (chemical, laminar, biosafety cabinet, etc)

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**Measuring and Protective Instrument**

**Analytical Radiation Detection Equipment:** List the type (liquid scintillation counter, gamma counter, etc.), manufacturer, model number (if known), and location of any analytical equipment used with this protocol

Type	Make & Model	Location

**Portable Radiation Survey Instruments:** List the type(s), e.g. Geiger counter, scintillation detector, ion chamber, manufacturer and model number(s) of portable radiation survey instruments available in the facility.

Type	Make & Model	Probe Type/Model No.

Describe available shielding:

---

**Waste:** Indicate the type of waste and the disposal category that will be generated:

- Solid  Aqueous Liquid       Organic Liquid      Liquid Scintillation Fluids:  Regulated       Unregulated  
 Animal Carcasses

**Provide justification for use of regulated liquid scintillation fluids:**

**Arrangements for special problems such as carcass storage for animals.**

---

**Personnel:** List the name(s) of personnel who will be working with radioactive materials under the authorization for this project and their social security number (for tracking purposes).

First name	Last name	Sex (F, M)	SS#	Radiation safety training

Note: All personnel working with or near radioactive materials must register with EHS as a radiation worker and receive training.

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**Certification**

I agree to conduct activities under the authorization for this project in full compliance with all applicable federal, state and local regulations, and EHS policies.

Signature: \_\_\_\_\_

Date: \_\_\_\_\_

Appendix C

[PA State Form - Notice to Employees](#)