INTRODUCTION

This revision of the Radiation Safety Manual was approved by the Radiation Safety Committee (RSC) and supersedes all other revisions. It also supersedes and takes precedence over any memoranda, notices or condensed versions issued prior to the date of issuance of this manual.

In this manual are the policies and standards for work with radiation and radioactive materials at the University of Rochester. These policies and standards must govern all work at University laboratories involving the use of radionuclides, work at the laboratory for laser energetic (LLE), all X-ray machines, and other sources of ionizing radiation.

These radiation safety policies meet all regulatory requirements of the Nuclear Regulatory Commission, the New York State Department of Health and the New York State Department of Environmental Conservation.

The requirements of this document apply to all personnel working with radiation or radioactive materials at the University of Rochester or under the cognizance of the University of Rochester’s radioactive materials license at any off-site location.
NOTICE

Some parts of this manual contain definitions and concepts taken from Part 16 of the New York State Sanitary Code. A copy of Part 16 (10 NYCRR 16) and other New York and Federal Guidance reports and regulations are available at Radiation Safety Office in the Medical Center, G-8842 and through the New York Department of Health website. Changes to these regulations may require corresponding changes to this manual.
Table of Contents

SECTION 1: DEFINITIONS ........................................................................................................6

SECTION 2: ADMINISTRATION AND OVERSIGHT OF THE RADIATION SAFETY
PROGRAM ..........................................................................................................................15
   ORGANIZATION FOR RADIATION SAFETY ...........................................16
   STANDING COMMITTEE ON RADIATION SAFETY .........................16
   ADVISORY COMMITTEE HUMAN USE OF RADIOISOTOPES ..............20

SECTION 3: DUTIES AND RESPONSIBILITIES OF THE RADIATION SAFETY
COMMITTEE ......................................................................................................................21
   Responsibilities .........................................................................................................21
   Duties ............................................................................................................................21

SECTION 4: DUTIES AND RESPONSIBILITIES OF THE RADIATION SAFETY
OFFICER ...........................................................................................................................23
   Responsibilities .........................................................................................................23
   Duties ............................................................................................................................23

SECTION 5: RESPONSIBILITY OF RADIOACTIVE MATERIALS PERMIT HOLDERS .......25

SECTION 6: POLICY FOR ADDRESSING VIOLATIONS OF REGULATORY
REQUIREMENTS OR STANDARDS FOR SAFE WORK WITH RADIATION AND RADIOACTIVE MATERIALS .................................................................28
   Policy ............................................................................................................................28
   Major Violations .........................................................................................................28
   Minor Violations .........................................................................................................30
   Examples of Possible Recommended Corrective or Disciplinary Actions ............31

SECTION 7: OCCUPATIONAL DOSE LIMITS .................................................................32
   7.1 Occupational Dose Limits for Adults .................................................................32
   7.2 Radiation Exposure During Pregnancy ...............................................................32
   7.3 Occupational Dose Limits for Minors .................................................................33
   7.4 Determination of Internal Doses ........................................................................33
   7.5 Radiation Dose Limits for Individual Members of the Public .........................33
   7.6 Radiation Dose Calculations for Pregnant Patients Exposed to
Diagnostic or Therapeutic Medical Procedures Utilizing
Ionizing Radiation ................................................................. 33

7.7 Reportable Dose Limits from Medical Exams ......................... 34

SECTION 8: PERSONNEL MONITORING ........................................ 35
8.1 Dosimeter Requirements ......................................................... 35
8.2 How to Obtain a Dosimeter ...................................................... 35
8.3 Wearing a Dosimeter .............................................................. 35
8.4 Proper Use of Dosimeters ....................................................... 36
8.5 Misuse of Dosimeters ............................................................. 36
8.6 Responsibility for Use of Dosimeters ......................................... 36
8.7 Periodic Exchange ................................................................. 37
8.8 Exposure Results ................................................................. 37
8.9 Radiation Dosimetry Reports ................................................... 37
8.10 Notification and Investigation of Exposures ................................ 37
8.11 Other Dosimetry Services ....................................................... 38
8.12 Visitors .............................................................................. 38

SECTION 9: REQUIREMENTS FOR POSTING/LABELING LABS USING
RADIOACTIVE MATERIAL ......................................................... 39
9.1 Radioactive Material Areas: Posting and Labeling ...................... 39
9.2 Empty Containers ................................................................... 39
9.3 Other Postings ....................................................................... 39
9.4 Misuse of Caution Signs .......................................................... 39

SECTION 10: CONTAMINATION AND RADIATION SURVEYS OF LABS
USING RADIOACTIVE MATERIAL ............................................... 40

SECTION 11: GUIDELINES FOR SAFE USE OF RADIOACTIVE MATERIAL .... 42

SECTION 12: SEALED AND UNSEALED RADIOACTIVE SOURCES .......... 44
12.1 Location ............................................................................ 44
12.2 Handling ............................................................................. 44
12.3 Transport of Sources ............................................................ 44
12.4 Sealed Source Irradiators ...................................................... 45
12.5 Storage of Radioactive Materials ............................................ 45

SECTION 13: PROCEDURE FOR OBTAINING RADIONUCLIDES .......... 46
13.1 Approval to Use Radioactive Material ...................................... 46
13.2 Orders for Radioactive Material .............................................. 46
13.3 Receipt of Radioactive Materials .............................................. 46
13.4 Radioactive Material with an Atomic Number Greater than 83 .......... 47

SECTION 14: OPENING RADIONUCLIDE CONTAINERS ................. 48
SECTION 15: RADIOACTIVE WASTE DISPOSAL ................................................. 49
  15.1 General Rules ................................................................. 49
  15.2 Radioactive Waste Storage, Processing, and Disposal ............ 50

SECTION 16: ANIMALS CONTAINING RADIOACTIVITY ............................ 51

SECTION 17: PROCEDURES IN CASE OF RADIOLOGICAL INCIDENTS ........ 52
  17.1 Incident Reporting ........................................................... 52
  17.2 Radiological Incidents ....................................................... 52
     Spill of radioactive material .............................................. 52
     Skin contamination ............................................................. 54
     Ingestion or inhalation of radioactive materials ..................... 54
     Exposure to abnormal and high levels of x-ray, beta, gamma, or neutron radiation ........................................... 55
     Loss of radioactive materials .............................................. 55
     Fire or flooding involving radioactivity ................................ 56
     Malfunction of radiation-producing machinery ....................... 56

SECTION 18: STORAGE OF RADIOACTIVE MATERIALS ............................... 57

SECTION 19: TRANSPORTATION OF RADIOACTIVE MATERIALS ............. 58
  19.1 Incoming Radioactive Material Shipments .......................... 58
  19.2 Outgoing Shipments of Radioactive Material ....................... 58
  19.3 Reports of Damaged Shipments ........................................ 58

SECTION 20: RADIATION-GENERATING DEVICES .................................... 59
  20.1 Hazards from Radiation-Generating Devices ......................... 59
  20.2 Rules for Safe Operation .................................................. 59
     20.2.1 General Requirements ............................................... 59
     20.2.2 Fluoroscope Operation ............................................... 60
     20.2.3 Medical X-rays ....................................................... 60
     20.2.4 Radiation Therapy .................................................... 60

SECTION 21: USER TRAINING PROGRAMS ................................................. 61
  21.1 Training and Experience for Medical Uses of Radioactive Material .... 61
     21.1.1 Diagnostic Procedures-Group I: Uptake, Dilution, and Excretion Studies ........................................... 61
  21.2 Training for Non-Medical Uses of Radioactive Material ............ 61
  21.3 Training and Experience for Users of Gamma-Ray Irradiators .... 62

SECTION 22: MEDICAL USE OF RADIOACTIVE MATERIALS ....................... 64
  22.1 Outpatients ................................................................. 64
  22.2 All Inpatient Treatments Utilizing Radioactive Materials .......... 64
  22.3 Inpatient Radiopharmaceutical Therapy .................................. 65
22.4  Radiation Safety for Therapeutic Use of Sealed Sources in Implants .....66
22.5  Radioactive Cadavers ..............................................................................68
22.6  Management of Patients in the Operating Room ......................................68
22.7  Transport of Patients ...............................................................................68
22.8  Surgical Removal or Biopsies of Tissues Containing Radioactivity ..........69

SECTION 23: OPERATION OF LLE’S TRITIUM FILLING STATION AND OMEGA
          LASER SYSTEM ................................................................................70
          23.1  Sources and Production of Radiation ..................................................70
          23.2  Operating Procedures .........................................................................70

SECTION 24: EXPERIMENTAL AND MEDICAL USE OF IODINE AND
          VOLATILE COMPOUNDS ......................................................................73
          24.1  Precautions for Working with All Volatile Compounds
               (Including Iodine Isotopes) .................................................................73
          24.2  Additional Precautions for Working with Radioactive Iodine
               Compounds ........................................................................................74

SECTION 25: MAINTENANCE ON CONTAMINATED OR POTENTIALLY
          CONTAMINATED EQUIPMENT .................................................................75

Appendix A
Current Radioisotopes used at UR .................................................................76

Appendix B
Radiation Safety Officer (RSO) notification references ..................................78

Appendix C
Radiation Exposure Policy ............................................................................80

REFERENCES ................................................................................................81
SECTION 1: DEFINITIONS

1.1 Definitions

Absorbed dose – The energy imparted by ionizing radiation per unit mass of irradiated material. The units of absorbed dose are the Gray (Gy) and the Rad.

Activity – The rate of disintegration or transformation or decay of radioactive material. The units of activity are the Becquerel (Bq) and the curie (Ci).

Adult – An individual 18 years, or more, of age.

Airborne radioactive material – Any radioactive material dispersed in the form of dusts, fumes, particulates, mists, vapors, or gases.

Airborne radioactive area – A room, enclosure, or area in which airborne radioactive materials exist in concentrations:

(i) in excess of the derived air concentrations (DACs) specified in Appendix 16-C, Table 1, Column 3 of 10 NYCRR 16;

(ii) to such a degree that an individual present in the area without respiratory protective equipment could exceed, during the hours an individual is present in a week, an intake of 0.6 percent of the annual limit of intake (ALI) or 12 DAC-hours.

Annual limit of intake (ALI) – The derived limit for the amount of radioactive material taken into the body of an adult worker by inhalation or ingestion in a year. ALI is the smaller value of intake of a given radionuclide in a year by the reference man that would result in a committed effective dose equivalent of 0.05 Sievert (5 rem) or a committed dose equivalent of 0.5 Sievert (50 rem) to any individual organ or tissue. ALI values for radionuclides are given in Section 26 Table 1.

As low as reasonably achievable (ALARA) – Making every reasonable effort to maintain exposures to radiation as far below the dose limits in this part as is practical consistent with the purpose for which the licensed activity is undertaken, taking into account the state of technology, the economics of improvements in relation to state of technology, the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations, and in relation to utilization of nuclear energy and licensed materials in the public interest.

Authorized user – Means a physician, dentist or podiatrist who is identified as a user on a Commission State or Agreement State license that authorizes use of the medical use of byproduct material.

Authorized user (under UR RAM permit) - Any person authorized to use radioactive materials at the University of Rochester. Permit holders and radiation workers are two examples of authorized users.

Background radiation – Radiation from cosmic sources; naturally occurring radioactive materials, including radon, except as a decay product of source or special nuclear material, and including global fallout as it exists in the environment from the testing of
nuclear explosive devices. Background radiation does not include sources of radiation from radioactive materials regulated by the NYSDOH.

**Becquerel** (Bq) – Equal to one disintegration or transformation per second (s⁻¹).

**Bioassay** – The determination of kinds, quantities or concentrations, and, in some cases, the locations of radioactive material in the human body, whether by direct measurement, in vivo counting, or by analysis and evaluation of materials excreted or removed from the body.

**Calendar quarter** – Not less than 12 consecutive weeks nor more than 14 consecutive weeks. The first calendar quarter of each year must begin in January, and subsequent calendar quarters must be so arranged that no such day is included in more than one calendar quarter and no day in any one year is omitted from inclusion within a calendar quarter.

**Calibration** – The determination of:

(i) the response or reading of an instrument relative to a series of known radiation values over the range of the instrument, or

(ii) the strength of a source of radiation relative to a standard.

**Class** – A classification scheme for inhaled material according to its rate of clearance from the pulmonary region of the lung. Materials are classified as D, W, or Y, which applies to a range of clearance half-times: for Class D (days), of less than 10 days; for Class W (weeks), from 10 to 100 days; and for Class Y (years), of greater than 100 days.

**Committed dose equivalent** (Hₜ,₅₀) – The dose equivalent to organs or tissues of reference (T) that will be received from an intake of radioactive material by an individual during the 50-year period following the intake.

**Committed effective dose equivalent** (Hₑ,₅₀) – The sum of the products of the weighting factors applicable to each of the body organs or tissues that are irradiated and the committed dose equivalent to each of these organs or tissues (Hₑ,₅₀ = wᵢ Hₜ,₅₀).

**Contamination** – The deposition of radioactive material in any place where it is not desired (units = dpm/100 cm²).

**Controlled area** – Any area where access is controlled for the purpose of protecting individuals from exposure to radiation and radioactive material, but must not mean any area used as residential quarters. “Controlled area” is synonymous with “restricted area.”

**Curie** (Ci) – A unit of activity. One curie is that quantity of radioactive material that decays at the rate of 3.7 × 10¹⁰ Bq.

**Decay chain** (Series) – A series of isotopes resulting from the decay of a parent nuclide and its subsequent radioactive daughters to an ultimate stable form.

**Decay constant** – the fraction of the number of atoms that will decay in a unit period of time.

\[
DC = \frac{\ln(2)}{t \frac{1}{2}}
\]

\[
\ln(2) = \text{natural logarithm of 2 ~ 0.693…}
\]


\[ t^{1/2} = \text{isotope half-life} \]

**Declared pregnant woman** – A woman who has voluntarily informed her employer, in writing, of her pregnancy.

**Deep dose equivalent** (\(H_d\)) – The dose exposure at a tissue depth of 1 centimeter (applies to external whole body exposure). (1000 mg/cm²)

**Derived air concentration** (DAC) – The concentration of a given radionuclide in air, which, if breathed by the reference man for a working year of 2,000 hours under conditions of light work, results in an intake of one ALI. For purposes of this manual, the condition of light work is an inhalation rate of 1.2 cubic meters of air per hour for 2,000 hours in a year. DAC values for radionuclides are given in Section 26 Table 1.

**Derived air concentration-hour** (DAC-hour) – The product of the concentration of radioactive material in air, expressed as a fraction or multiple of the derived air concentration for each radionuclide, and the time of exposure to that radionuclide in hours. A licensee or registrant may use 2000 DAC-hours to represent one ALI, equivalent to a committed effective dose equivalent of 0.05 Sv (5 rem).

**Dose** – A generic term that means absorbed dose, dose equivalent, effective dose equivalent, committed dose equivalent, committed effective dose equivalent, effective dose equivalent, or total effective dose equivalent.

**Dose equivalent** (\(H_T\)) – The product of the absorbed dose in tissue, quality factor, and all other necessary modifying factors at the location of interest. The units of dose equivalent are the Sievert (Sv) and rem. Dose must be officially tracked using SI units.

**Dose limits** – The permissible upper bounds of radiation doses established in accordance with these regulations. For purposes of these regulations, “limits” is an equivalent term.

**Dose meter** – An instrument designed to measure the dose rate of ionizing radiation—usually displayed in µSv/hr or mR/hr.

**Dose rate** – Absorbed dose delivered per unit time (Grays/hr or rads/hr).

**Dosimeter** – An instrument used to detect and measure accumulated radiation exposure.

**Dosimetry** – The theory and application of the principles and techniques involved in the measurement and recording of radiation doses. Its practical aspect is concerned with the use of various types of radiation instruments with which measurements are made.

**Effective dose equivalent** (\(H_E\)) – The sum of the products of the dose equivalent to each organ or tissue (\(H_T\)) and the weighting factor (\(W_T\)) applicable to each of the body organs or tissues that are irradiated (\(H_E = \Sigma W_T H_T\)).

**Element** – A category of atoms having the same number of protons and the same chemical properties.

**Exposure** –

(i) being exposed to ionizing radiation or to radioactive material; or

(ii) the quotient of dQ by dm, where “dQ” is the absolute value of the total charge of the ions of one sign produced in air when all the electrons
(negatrons and positrons) liberated by photons in a volume of air having a mass “dm” are completely stopped in air. The special unit of exposure is the roentgen. One roentgen is equal to $2.58 \times 10^{-4}$ coulomb per kilogram of air.

**Exposure rate** – The exposure per unit of time, such as roentgen per minute and milliroentgen per hour.

**External dose** – That portion of the dose equivalent received from any source of radiation outside the body.

**Extremity** – The hand, elbow, arm below the elbow, foot, knee, and leg below the knee.

**Eye dose equivalent** – The external dose equivalent to the lens of the eye at a tissue depth of 0.3 cm. (300mg/cm²). Also referred to as Lens dose equivalent (LDE).

**Fixed Contamination** – The radioactivity remaining on a surface after repeated decontamination attempts fail to significantly reduce the contamination level.

Regarding requirements for packaging, preparation for shipment, and transportation of licensed material:

**Gray** (Gy) – The SI unit of absorbed dose. One Gy is equal to an absorbed dose of 1 joule/kilogram. The Gy typically is used for deterministic effects, such as skin dose or eye dose. One Gy is equal to 100 rad.

**Half-life** (biological) – The amount of time required for $\frac{1}{2}$ of an ingested, inhaled, or administered substance to be eliminated from the body.

**Half-life** (effective) – The amount of time required for radioactive material in the body to have its activity reduced by 50% by a combination of radioactive decay and elimination.

**Half-life** (radiological) – The amount of time that is required for a radioactive substance to lose $\frac{1}{2}$ of its activity.

**Half-value layer** (HVL) – The amount of material required to reduce the dose rate from a radiation source by a factor of 2.

**High-radiation area** – Any area, accessible to individuals, in which radiation levels could result in an individual receiving in excess of 1 mSv (0.1 rem) in 1 hour at 30 centimeters from any source of radiation or from any surface that the radiation penetrates. For purposes of these regulations, rooms or areas in which diagnostic X-ray systems are used for healing arts purposes are not considered high radiation areas.

**Human use** – The internal or external administration of radiation or radioactive material to human beings.

**Incident** – Any unexpected event involving radiation or radioactivity with the potential for the spread of radioactive contamination, skin contamination, uptake of radioactive materials, exposure to elevated radiation levels, loss of radioactive material, and so forth.

**Individual monitoring** – the assessment of
(i) Dose equivalent
   (a) by the use of individual monitoring devices, or
   (b) by the use of survey data; or

(ii) Committed effective dose equivalent
   (a) by bioassay, or
   (b) by determination of the time-weighted air concentrations to which an individual has been exposed, that is, DAC-hours.

**Individual monitoring devices** – Devices designed to be worn by a single individual for the assessment of dose equivalent. Individual monitoring equipment and personnel monitoring equipment are equivalent terms. Examples of individual monitoring devices are thermo-luminescent dosimeters (TLDs), InstaDose dosimeters, DoseAware dosimeters and personal air sampling devices.

**Internal dose** – That portion of the dose equivalent received from radioactive material taken into the body.

**Isotope** – An atom of the same atomic number (containing the same number of protons) but with a different number of neutrons in the nucleus (different atomic mass) – can be stable or radioactive.

**KERMA** – Kinetic Energy Released in a Material. A measure of dose to the air. The KERMA dose is equivalent to the skin dose under conditions of electronic equilibrium.

**License** – A radioactive material license issued by the New York State Department of Health in accordance with the regulations adopted by that department.

**Licensed material** – Radioactive material received, possessed, used, transferred, or disposed of under a general license or specific license issued by the New York State Department of Health.

**Monitoring** – The measurement of radiation, radioactive material concentrations, surface area activities, or quantities of radioactive material, and the use of the results of these measurements to evaluate potential exposures and doses.

**NARM** – Naturally occurring Accelerator-produced Radioactive Material—material that is either naturally radioactive or has been made radioactive by bombardment with high-energy particles or ions in an accelerator.

**NORM** – Naturally Occurring Radioactive Material—material that is naturally radioactive due to containing naturally occurring radioactive isotopes.

**Nuclide** – A species of atom characterized by the constitution of its nucleus and capable of more than a transient existence.

**Nuclide (daughter)** – An atom characterized by the number of protons in its nucleus AND its energy level [ex: Tc-99m is a different nuclide than Tc-99, exhibiting a different half-life and different decay energies due to its existing in a different nuclear excitation (meta-stable) state].
**Nuclide** (parent) – The nuclide that exists prior to radioactive decay, decaying to form the daughter nuclide.

**Occupational dose** – The dose received by an individual in the course of employment in which the individual’s assigned duties involve exposure to sources of radiation, whether in the possession of the licensee, registrant, or other person. Occupational dose does not include doses received from natural background radiation, as a patient from medical practices, from voluntary participation in medical research programs, or as a member of the public.

**Permit holder** – The person who has been granted a radioactive materials permit by the RSC. A permit holder typically holds a position as a member of the academic, medical, or research faculty. Any person listed as the Principle Investigator on a research grant must be a permit holder in the absence of a waiver from the RSC. Under NY regulations, a permit holder must have 40 hours of documented work experience with radioactive materials prior to receiving approval from the RSC.

**Protective Apron** – An apron made of radiation attenuating material(s), used to reduce exposure to radiation. It must be a minimum of 0.25 mm lead equivalent and cover the neck to lower thigh. UR recommends 0.5 mm equivalent and lead glasses/goggles. Gloves for holding must be 0.5 mm lead equivalent. Patient gonadal shield must be 0.5 mm lead equivalent. Protective aprons must be inventoried and inspected twice a year. Inspections need only be visual and tactile. Protective devices are cleaned to remove any contaminants and prevent the spread of infection.

**Quality factor (Q)** – The conversion factor used to derive dose equivalent from absorbed dose.

(i) The quality factors for converting absorbed dose to dose equivalent are shown in Table 1 at the end of this section.

(ii) Quality factors for neutron radiation are found in Table 2, 10 NYCRR Part 16.2.

**Rad** – An older unit of absorbed dose. One rad is equal to an absorbed dose of 100 erg/gram or 0.01 joule/kilogram (0.01 Gy). One millirad equals 0.001 rad.

** Radiation** – Alpha particles, beta particles, gamma rays, x-rays, neutrons, high-speed electrons, high-speed protons, and other particles capable of producing ions. For purposes of this manual, ionizing radiation is an equivalent term.

** Radiation area** – Any area, accessible to individuals, in which radiation levels could result in an individual receiving a dose equivalent in excess of 0.05 mSv (0.005 rem) in 1 hour at 30 centimeters from the source of radiation or from any surface that the radiation penetrates.

** Radiation equipment** – Any equipment or device that can emit radiation through several means. Such equipment includes x-ray units, linear accelerators, and irradiators.

** Radiation Safety Officer (RSO)** – An individual who, under the authorization of the operator of a radiation installation, administers a radiation protection program in accordance with section 16.5 of this Part (NYS Part 16) and who is qualified by training
and experience in radiological health to evaluate the radiation hazards of such installation and administer such radiation protection program.

**Radiation Safety Unit (RSU)** – University of Rochester unit responsible for all activities dealing with radioactive material and radiation producing equipment. Services provided include monitoring laboratories for safe use of radioisotopes, inspecting radiation producing equipment, ordering radioactive materials for the University community and arranging for disposal of these materials.

**Radiation source** – Any radioactive material or any radiation equipment.

**Radioactive material** – Any solid, liquid, or gas that emits radiation spontaneously.

**Radiation worker** – Any person who, because of their work, is likely to receive a dose of 1 mSv (100 mrem) or greater in one year from working with or around occupational radiation or radioactive materials. All radiation workers must receive training prior to commencing work with radiation or radioactive materials.

**Radioactivity** – The property of certain nuclides of spontaneously emitting particles or gamma radiation following orbital electron capture, electron emission, isometric transition, nuclear rearrangement, or spontaneous fission.

**Radionuclide** – a radioactive nuclide.

**Rem** – The special unit of any of the quantities expressed as dose equivalent. The dose equivalent in rems is equal to the absorbed dose in rads multiplied by the quality factor (1 rem=0.01 sievert).

**Removable Contamination** – The radioactivity that can be transferred from a surface to a smear test paper by rubbing with moderate pressure.

Regarding requirements for packaging, preparation for shipment, and transportation of licensed material:

**Non-Fixed Contamination** – The contamination that can be removed from a surface during normal conditions of transport.

**Respiratory protective equipment** – An apparatus, such as a respirator, used to reduce an individual’s intake of airborne radioactive material.

**Restricted area** – Any area, access to which is limited by the licensee for the purpose of protecting individuals against undue risks from exposure to sources of radiation.

**Roentgen** – An older special unit of air exposure. One roentgen equals $2.58 \times 10^{-4}$ coulomb/kilogram of air (See Exposure).

**Sanitary sewerage** – A system of public sewers for carrying off waste and refuse, but excluding sewage treatment facilities, septic tanks, and leach fields owned or operated by the licensee or registrant.

**Sealed source** – Radioactive material that is permanently bonded or fixed in a capsule or matrix designed to prevent release and dispersal of the radioactive material under the most severe conditions that are likely to be encountered in normal use and handling.
**Shallow dose equivalent (H_s)** – The dose equivalent at a tissue depth of 0.007 centimeter averaged over an area of 1 square centimeter (applies to the external exposure of the skin or an extremity).

**SI** – An abbreviation of the International System of Units.

**Sievert** – The SI unit of any of the quantities expressed as dose equivalent. The dose equivalent in Sievert is equal to the absorbed dose in Gy multiplied by the quality factor (1 Sv = 100 rem).

**State** – The State of New York.

**Stochastic effect** – A health effect that occurs randomly and for which the probability of the effect occurring, rather than its severity, is assumed to be a function of dose without threshold. Hereditary effects and cancer incidence are examples of stochastic effects.

**Survey** – An evaluation of the radiological conditions and potential hazards incident to the production, use, transfer, release, disposal, or presence of sources of radiation. When appropriate, such evaluation includes, but is not limited to, tests, physical examinations, and measurements of levels of radiation or concentrations of radioactive material present.

**Total effective dose equivalent** (TEDE) – The sum of the deep dose equivalent for external exposures and the committed effective dose equivalent for internal exposures.

**Uranium** (natural) – Uranium containing the relative abundance of isotopes found in nature (U-238, 99.275%; U-234, 0.005%).

**Uranium** (depleted) – Uranium containing less than 0.720% U-235.

**Uranium** (enriched) – Uranium containing more than 0.720% U-235.

**Very high radiation area** – An area, accessible to individuals, in which radiation levels could result in an individual receiving an absorbed dose in excess of 5 Gy (500 rad) in 1 hour at 1 meter from a source of radiation or from any surface that the radiation penetrates.

**Weighting factor** (W_T) – For an organ or tissue (T) means the proportion of the risk of stochastic effects resulting from irradiation of that organ or tissue to the total risk of stochastic effects when the whole body is irradiated uniformly. For calculating the effective dose equivalent, the values of W_T are

<table>
<thead>
<tr>
<th>Organ or Tissue</th>
<th>Organ Dose Weighting Factors (NCR 10CFR20.1003)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gonads</td>
<td>0.25</td>
</tr>
<tr>
<td>Breast</td>
<td>0.15</td>
</tr>
<tr>
<td>Red bone marrow</td>
<td>0.12</td>
</tr>
<tr>
<td>Lung</td>
<td>0.12</td>
</tr>
<tr>
<td>Thyroid</td>
<td>0.03</td>
</tr>
<tr>
<td>Bone surfaces</td>
<td>0.01</td>
</tr>
<tr>
<td>Remainder</td>
<td>0.32^a</td>
</tr>
<tr>
<td>Whole body</td>
<td>1.00^b</td>
</tr>
</tbody>
</table>
a 0.32 results from 0.025 for each of 13 “remainder” organs, excluding the skin and the lens of the eye, that receive the highest doses (0.6 each).
b For purposes of weighting the external whole body dose, for adding it to the internal dose, a single weighting factor, \( W_T = 1.0 \), has been specified. The use of other weighting factors for external exposure will be approved on a case-by-case basis until such time as specified guidance is issued.

**Whole body** – For purposes of external exposure, head, trunk (including male gonads), arms above the elbow, or legs above the knee.

**16 NYCRR** – The section of the New York Code of Rules and Regulations pertaining to radiation safety.

<table>
<thead>
<tr>
<th>Type of Radiation</th>
<th>Quality Factor (Q)</th>
<th>Absorbed Dose Equal to a Unit Dose Equivalent(^a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>X, gamma, beta radiation, high-speed electrons</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Alpha particles and other heavy charged particles</td>
<td>20</td>
<td>0.05</td>
</tr>
<tr>
<td>Neutrons of unknown energy</td>
<td>10</td>
<td>0.01</td>
</tr>
<tr>
<td>High-energy protons</td>
<td>10</td>
<td>0.01</td>
</tr>
</tbody>
</table>

\(^a\)Absorbed dose in rad equal to 1 rem or the absorbed dose in Gy equal to 1 Sv.
SECTION 2: ADMINISTRATION AND OVERSIGHT OF THE RADIATION SAFETY PROGRAM

The University of Rochester Board Of Trustees established a Standing Committee on Radiation Safety in a resolution passed on October 16, 1961. This resolution was revised in 1965. The Committee is to give proper and continuing recognition to problems relating to all potential radiation hazards resulting from the activities of the University. The Committee is further charged with establishing and maintaining appropriate procedures for the procurement, use, and care of all radioactive sources and radiation-producing machines within the entire University. This is to ensure compliance with existing state and federal requirements and is to afford a maximum degree of protection to University personnel, students, patients, visitors, and the general public from radiation hazards arising out of the use of radiation-producing sources and machines. The duties and responsibilities of the Committee required by regulations are listed in Section 3 of this manual.

Procedures developed by the Committee are published in the Radiation Safety Manual and are presented to the Office of the President for review and approval. The Standing Committee on Radiation Safety meets quarterly. Additional ad-hoc members of the committee may be added at the discretion of the Chairman of the RSC. The Chairman of this Committee will furnish the Office of the President with an annual report on the activities of the Committee. The RSU provides an annual report of its activities to the RSC.

The Human Use of Radioisotopes Committee (HURC) meets quarterly to review, comment on, and approve all research protocols involving human subjects because of the additional precautions that must be taken for such research. Additional committees include the Radiation Safety Advisory Committee (RSAC), the Radioactive Drug Research Committee (RDRC), and the Medical X-ray Quality Assurance Committee (QAC). All of these committees are independent of the RSC although they may submit reports to the RSC.

The responsibility for ensuring that approved procedures are carried out, including the rules and regulations of the University and the governing public agencies regarding radiation safety, is assigned to the RSO. The RSO reports to a member of the University of Rochester Administration who does not use or supervise the use of radiation or radioactive materials. The RSO is responsible for identifying radiation safety problems; initiating, recommending, or providing corrective actions; and verifying implementation of corrective actions. Other duties of the RSO are enumerated in Section 3 of this manual.

Violations of legal requirements or of the policies set forth in this manual will be brought to the attention of the responsible permit holder, who will be required to take appropriate corrective actions. Failure to properly resolve a violation will be brought to the attention of the RSC Chair and University Administration. Instances of repeated violations will be reviewed by the RSC and may result in suspension of approval to use radiation-producing equipment or radioactive materials.
ORGANIZATION FOR RADIATION SAFETY

Board of Trustees
Office of the President
Office of the Vice President for Health Affairs
Director of Environment Health and Safety
Radiation Safety Officer
Radiation Safety Unit

STANDING COMMITTEE ON RADIATION SAFETY

Chair, Radiation Safety Committee (appointed by the University President)
One representative from senior University or Medical Center Administration
Radiation Safety Officer
Chair, Department of Radiology
Chair, Nuclear Medicine
Chair, Department of Radiation Oncology
Chair, Department of Cardiology
Representative from Nursing Practice
Three representatives from the Departments of Chemistry, Physics, and/or Biology
Three representatives from the research faculty or staff of the School of Medicine and Dentistry
One representative from the Laboratory for Laser Energetics
Director of Research Administration
# RADIATION SAFETY COMMITTEE MEMBERSHIP
## 2021–2022

<table>
<thead>
<tr>
<th>Name</th>
<th>Title</th>
<th>Box Number and Phone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shmayda, Dr. Walter, Ph.D.</td>
<td>Radiation Safety Committee Chair, University of Rochester and Radiation Safety Officer, Laboratory for Laser Energetics, University of Rochester</td>
<td>278871 5-5769</td>
</tr>
<tr>
<td>Matloubieh, Ahmad, LMP</td>
<td>Acting Radiation Safety Officer, UR Medicine, Highland Hospital</td>
<td>100 South Ave 341-6279</td>
</tr>
<tr>
<td>Barber, Lori Ann, RT</td>
<td>Radiation Safety Technologist, Radiation Safety Unit, Environmental Health and Safety, University of Rochester</td>
<td>HPH 623-0524</td>
</tr>
<tr>
<td>Cavanaugh, Mark</td>
<td>Director, Environmental Health and Safety, University of Rochester</td>
<td>278878 5-8412</td>
</tr>
<tr>
<td>Chengazi, Dr. Vaseem, MD</td>
<td>Provider, Nuclear Medicine, Department of Imaging Sciences, University of Rochester</td>
<td>648 5-4741</td>
</tr>
<tr>
<td>Fenicchia, Karen, RN</td>
<td>Nurse Administrator, QA Admin, Department of Imaging Sciences, University of Rochester</td>
<td>648 3-5328</td>
</tr>
<tr>
<td>Harvey, Jennifer, MD</td>
<td>Department Chair, Department of Imaging Sciences, University of Rochester</td>
<td>648 5-2734</td>
</tr>
<tr>
<td>Kozak, Kristen, RT (R)</td>
<td>Manager of Clinical Operations, Department of Imaging Sciences, University of Rochester</td>
<td>648 5-5192</td>
</tr>
<tr>
<td>Name</td>
<td>Title</td>
<td>Contact Information</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-----------------------------------------------------------------------</td>
<td>--------------------------------------</td>
</tr>
<tr>
<td>Mackin, Maria, CNMT</td>
<td>Supervisor, Nuclear Medicine, Department of Cardiology, University of Rochester</td>
<td>379 5-1430</td>
</tr>
<tr>
<td>Moody, Susan, BSRT (R) (M)</td>
<td>Clinical Manager, University Imaging at East River Road, University of Rochester</td>
<td>648 3-2812</td>
</tr>
<tr>
<td>Murray, Thomas, RT (R)</td>
<td>Clinical Director, Department of Imaging Sciences, University of Rochester</td>
<td>648 6-7377</td>
</tr>
<tr>
<td>Musial, Scott T</td>
<td>Administrator, UR Medicine Urgent Care, University of Rochester</td>
<td>655 3-4399</td>
</tr>
<tr>
<td>Pacella, Matthew, LMP</td>
<td>Clinical Medical Physicist, Department of Radiation Oncology, Wilmot Cancer Institute, University of Rochester</td>
<td>647 3-5367</td>
</tr>
<tr>
<td>Panzer, Dr. Robert, MD</td>
<td>Associate Vice President for Patient Quality and Safety, University of Rochester</td>
<td>MED 3-4438</td>
</tr>
<tr>
<td>Russo, Antonio, RT (R)</td>
<td>Assistant RSO, Clinical Coordinator CT, UR Medicine, FF Thompson Hospital</td>
<td>Canandaigua 396-6648</td>
</tr>
<tr>
<td>Schroeder, Dr. Udo, Ph.D.</td>
<td>Professor, Department of Chemistry, University of Rochester</td>
<td>270216 5-8263</td>
</tr>
<tr>
<td>Stoessel, Patricia, CNMT</td>
<td>Nuclear Medicine Tech, Department of Imaging Sciences, Strong West, University of Rochester</td>
<td>648 758-7509</td>
</tr>
<tr>
<td>Streb, Shyla, RT (R)</td>
<td>Clinical Manager, Department of Imaging Sciences, Strong West, University of Rochester</td>
<td>Strong West Imaging 758-7513</td>
</tr>
<tr>
<td>Name</td>
<td>Position and Affiliation</td>
<td>Contact Information</td>
</tr>
<tr>
<td>---------------------</td>
<td>-----------------------------------------------------------------------------------------</td>
<td>---------------------</td>
</tr>
<tr>
<td>Waldman, Dr. David, MD</td>
<td>Radiation Safety Officer, UR Medicine Noyes Health and Faculty, Imaging Sciences, University of Rochester</td>
<td>648 5-2733</td>
</tr>
<tr>
<td>Wandkte, Dr. Ben, MD</td>
<td>Radiation Safety Officer, UR Medicine, FF Thompson Hospital</td>
<td>Canandaigua 396-6633</td>
</tr>
<tr>
<td>Wiener, Dr. Roy, MD</td>
<td>Provider, Medicine M&amp;D—Cardiology, UR Medicine, Rochester Pulmonary Group, University of Rochester</td>
<td>679 RCPG 338-2700</td>
</tr>
</tbody>
</table>

*(Persons specified above may name representatives to take their place on the Committee with the exception of the RSC Chair and the RSO.)*
ADVISORY COMMITTEE HUMAN USE OF RADIOISOTOPES

Chairman and Members to be appointed by the Senior Vice President and Vice Provost for Health Affairs

APPROVED: 

[Signature]

President, University of Rochester
SECTION 3: DUTIES AND RESPONSIBILITIES OF THE RADIATION SAFETY COMMITTEE

The RSC meets quarterly to review the performance of the RSU and discuss issues relating to the safe and regulatory compliant use of radiation and radioactive materials at the University of Rochester. A quorum consists of not less than one half the RSC members and must include the committee Chairman and the RSO. Issues discussed may include, but are not limited to, activities of the RSO, RSU, Permit Holders with an excessive number of violations, proposed changes in policy, and reports by other committees dealing with radiological issues. Other items are discussed as necessary. The duties and responsibilities of the RSC are listed below. These are specified in the New York State Department of Health Radiation Guide 10.1, Rev. 2 (Guide for the Preparation of Applications for Medical Programs), Appendix B.

Responsibilities
The RSC must:

1. Ensure procedures for the procurement, use, and care of radioactive materials and radiation-producing machines within the University are established and maintained and that these procedures are in accordance with Department of Health (NYSDOH) regulations and conditions of the license.

2. Ensure that the RSO and RSU effectively administer the University’s Radiation Safety program to ensure that all use of radioactive materials and the operation of radiation-producing machines is accomplished safely and in accordance with all federal and state regulations and the conditions of the radioactive material license.

Duties
The RSC must:

1. Be familiar with all pertinent NYSDOH and other regulations, the terms of the radioactive materials license, and the information submitted in support of the request for the license and its amendments.

2. Ensure the training, experience, and qualifications of all prospective radioactive materials permit holders are sufficient to enable them to perform their duties safely and responsibly.

3. Monitor the University’s programs to maintain individual and collective doses as low as reasonably achievable, including quarterly ALARA reports.

4. Establish a table of investigation levels for occupational radiation exposure, which when exceeded will initiate an investigation and consideration of action by the RSO.

5. Approve the program that ensures that all individuals whose duties may require them to work in the vicinity of radioactive material (e.g., nursing, security, and housekeeping personnel) are properly instructed as required by Section 16.13 of 10 NYCRR 16.
6. Review the radiation safety program annually to determine that activities are being conducted safely and in accordance with federal and state regulations and the University’s radioactive material license. The review must include an examination of records, reports from the RSO, the results of NYSDOH inspections, written safety procedures and adequacy of the University’s management control system.

7. Oversee and ensure all diagnostic imaging devices meet the NYSDOH and FDA inspection requirements. Ensure that the documentation is accurate and complete.

8. Review the therapeutic radioactive materials quality assurance programs annually to determine that the programs are being conducted in accordance with NYSDOH regulations and conditions of the radioactive materials license.

9. Review and determine the adequacy of remedial action to correct any deficiencies identified in the radiation safety program or quality assurance programs.

10. Review and determine the adequacy corrective or disciplinary actions for Permit Holders with an excessive number of violations noted during laboratory visits.

11. Maintain written records of all committee meetings (including members present), documenting action, recommendations, and decisions.

12. Ensure that the radioactive materials license is amended, when necessary, prior to any changes in facilities, equipment, policies, procedures, radioactive material, possession limits, and personnel, as specified in the license.
SECTION 4: DUTIES AND RESPONSIBILITIES OF THE RADIATION SAFETY OFFICER

Responsibilities

The Radiation Safety Officer (RSO) must:

1. Ensure that safe radiological working conditions are established and maintained for all University personnel, students, patients, visitors, and the general public.
2. Ensure compliance with all pertinent federal, state, and local regulations.
3. Fulfill the duties of the RSO specified in the New York State Department of Health Radiation Guide 10.5, Rev. 2 (Guide for the Preparation of Applications for the Use of Unsealed Sources of Radioactive Materials). The manner in which each of these responsibilities is carried out is described in other sections of this manual.
4. Meet the training requirement of NRC 10 CFR 35.50

Duties

The specific duties of the RSO and the RSU include the following:

1. Perform general surveillance over all activities involving radioactive material and radiation-producing machines including routine monitoring, inspection, and special surveys of areas in which radioactive material is used or radiation-producing machines are operated.
2. Enforce compliance with rules and regulations, license conditions, and the conditions of permit approval specified by the RSC.
3. Monitor and maintain systems associated with the use, storage, or disposal of radioactive material.
4. Furnish consulting services on all aspects of radiation safety to personnel upon request.
5. Receive, open, and deliver shipments of radioactive material arriving at the University of Rochester and process outgoing shipments in accordance with state and federal regulations. This responsibility may be delegated provided that training in the applicable regulations is completed and the individual agrees to assume this added responsibility.
6. Distribute and process personnel-monitoring devices, determine the need for bioassays, maintain personnel exposure and bioassay records, and notify individuals and their supervisors of exposures.
7. Conduct training programs and otherwise instruct personnel in the proper procedures for the use of radioactive material prior to use, annually (refresher training), and as required by changes in procedures, equipment, regulations, etc.
8. Supervise and coordinate the radioactive waste disposal program, including maintaining waste storage and disposal records and monitoring effluents.
9. Store radioactive materials not in current use, including wastes.
10. Perform leak tests on sealed sources as required by state and federal regulations.

11. Maintain an inventory of all radioisotopes and limit the quantity of radionuclides to the amounts authorized by the license.

12. Terminate any work or project that is found to be a threat to health or property.

13. Maintain other records not specifically designated above (e.g., receipt, transfer, and survey records).

14. Provide periodic inspections of x-ray-generating equipment, including, but not limited to, x-ray machines, CT scanners, fluoroscopes, dental x-ray devices, electron microscopes, x-ray diffraction devices, and other machines that emit x-radiation by design. Perform these inspections at such a schedule that meets State and Federal requirements of safe to patient and staff operation.

15. Provide radiological coverage for medical procedures utilizing large amounts of radioactivity. Such coverage may include, but not be limited to, calculating radiological stay times for nursing staff, decontaminating patient rooms, verifying the complete withdrawal of radioactive sources upon completion of treatment, and ensuring the accountability of radioactive sources.

16. Recommend the funding structure necessary to ensure that the Radiation Safety Unit can continue to meet all applicable regulatory requirements and maintain high standards for the safe use of radiation and radioactivity. Fees will be implemented with the concurrence of the Radiation Safety Advisory Committee.
SECTION 5: RESPONSIBILITY OF RADIOACTIVE MATERIALS PERMIT HOLDERS

A radioactive material permit holder is defined as any researcher using radioactive materials in a research program. All persons who are listed as the Principle Investigator on an approved grant must obtain a radioactive material permit approval from a subcommittee of the RSC. The RSU will coordinate with the Office of Research and Project Administration to ensure that all grants involving the use of radioactive material obtain permits.

The use of radioactive materials at the University of Rochester is restricted to personnel authorized by a subcommittee of the RSC. This authorization is indicated by issuing a Radioactive Materials Permit specifying the name of the permit holder, the room(s) in which radioactive materials will be used, the isotope(s) to be used, and the maximum quantity of each isotope permitted to be held by that permit holder at any given time.

Permit holders are responsible for the safe use of all radioactive materials obtained under their permit or used in the laboratory space assigned under their permit. Permit holders are also responsible for ensuring that all applicable regulations and University of Rochester policies are followed at all times.

Radioactive materials permits are issued by the RSO on behalf of the RSC. Prospective permit holders must complete and submit an application package to the RSO, who will review the materials and submit them to a subcommittee of the RSC for consideration. An application package includes

- a researcher information sheet (Radiation Safety Form 0005 Part A),
- an experiment information sheet (Form 0005Part B),
- a map of the intended laboratory space, and
- a copy of the prospective permit holder’s curriculum vitae.

New York State regulations require that all permit holders document at least 40 hours of work experience with radioactive materials prior to receiving a permit. Personnel not meeting this requirement must work under a faculty mentor to gain this experience prior to receiving their own permit. Permit holders who are physicians using radioactive materials for patient treatment must meet other requirements that are described in greater detail in Section 21 of this manual.

If a permit holder will be absent from his/her laboratory for a prolonged period of time (in excess of four consecutive weeks) he/she must designate an alternate person to assume responsibility for their permit during their absence. The alternate must be a person approved by a subcommittee of the RSC as a permit holder. In the absence of a designated alternate, the permit must be inactivated, all radioactive materials collected for storage or disposal, and the laboratory space closed out radiologically (surveyed and all radiological signs removed). Other specific responsibilities of permit holders are noted below.

It is the responsibility of all radioactive materials permit holders to
1. Apply for permission to use radioactive materials using forms 5A and 5B. A copy of Form 5B must be completed for each different experimental use of radionuclide. Copies of administrative forms are contained in Appendix A and can be found at the RSU WWW site.

2. Apply to amend the Radioactive Materials Permit for any changes in laboratory space, nuclide(s) to be used, in maximum possession limits, in the chemical form of radioisotopes to be used prior to commencing a new experimental protocol, or upon completion of experiments or protocols using radioactive materials (as described on a form 5B).

3. Notify Radiation Safety via a permit amendment request of the completion of an experiment or plans to terminate the use of radioactive materials at the University of Rochester. Such notification must be made at least four weeks before leaving the University to allow for proper permit termination and billing of final charges. Any charges that cannot be billed to the researcher will be billed to the appropriate department.

4. Ensure that surveys for radioactive contamination are performed and documented weekly when radioactive materials are in use and that these surveys are performed with the appropriate instrumentation.

5. Administer and enforce radiation safety rules and regulations in all areas within the scope of their authority. Ensure that each experimenter properly controls any contamination in his/her work area and that appropriate surveys are performed when work has been completed. If routine contamination above regulatory limits is detected, the experimenter must inform the RSU and decontaminate the area.

6. Inform all employees and students of potential health hazards and the safeguards that are established to ensure safe exposures.

7. Ensure that all employees and students working with, or in the vicinity of, radionuclides or radiation-producing equipment are properly monitored in accordance with the established personnel-monitoring programs. This includes the timely exchange of dosimeters and other personnel-monitoring devices according to the schedule provided and the performance of bioassays subsequent to the use of greater than 1mCi of iodine or 80 mCi of tritium.

8. Maintain control over radioactive materials by proper inventory, receipt and disposal of radioactive materials, and collection of contaminated materials. This inventory must be in the form of a written log book, which must contain as a minimum: the date of acquisition; the initial amount received (in Bq, µCi or mCi); the amounts actually used; the amounts on hand; corrections for radioactive decay; and the amounts disposed of as radioactive waste. HP Form 8, “Radioisotope Inventory Log Sheet,” is used to record these entries. In addition, a semiannual inventory is performed by Radiation Safety.

9. Ensure that all radioactive waste is delivered to Radiation Safety for disposal. All waste must be in sealed containers supplied by Radiation Safety and labeled with a waste tag or sheet containing the following information: contact person, date, isotope and decay-corrected activity of each isotope (in Bq, µCi or mCi); chemicals
present in the waste container; stock vial number(s) (HPA inventory number) from which the waste originated; and the laboratory in which the waste originated. Radioactive waste is NEVER to be left unattended in hallways. Liquid radioactive waste may NOT be disposed of via laboratory sinks unless specifically authorized in writing by the RSO.

10. Ensure safe and secure storage of all radioactive materials. Unless the storage area is in a Radiation Area, the radiation field produced by such storage must not exceed 5 μSv/hr (0.5 mR/ hr) at 30 cm from the source of radiation.

11. Notify Radiation Safety of the acquisition of any radiation-producing equipment including, but not limited to, x-ray machines, electron microscopes, and x-ray diffraction equipment.

12. Notify Radiation Safety of the acquisition of any equipment containing radioactive sealed sources. Examples of such equipment are analytical balances, liquid scintillation counters, and gas chromatographs.

13. Review and develop procedures to ensure that all radiological work is conducted safely. Standard Operating Procedures maintained by Radiation Safety may be used, if appropriate, in lieu of developing laboratory-specific procedures.

14. Inform Radiation Safety of all instances of radioactive contamination in excess of 500 dpm/100 cm² of beta/gamma on fixed surfaces outside a controlled surface contamination area. Fixed surfaces include floors, walls, bench tops (on the bench itself, not on removable materials placed on the bench top), and fume hood walls.

15. Notify Radiation Safety of any prolonged absences (in excess of four consecutive weeks) and designate an alternate Permit Holder for this period.

16. Notify Radiation Safety immediately in the event of any radiological emergencies such as spills of radioactive materials, contamination of laboratory personnel, or the loss of radioactive materials.

17. Ensure all radioactive materials users have received radiation safety training prior to commencing work with radioactive materials and that they complete annual refresher training.

Noncompliance with above responsibilities is in violation of University regulations and state and federal laws and jeopardizes both safety and the license of the University to use radioactive material. Failure to comply with the requirements specified in this manual may result in the withdrawal of approval for the noncompliant investigator to use radionuclides, the collection of radionuclides by the RSU, and curtailment of the research or other activities. These policies are described in Section 5 of this manual.
SECTION 6: POLICY FOR ADDRESSING VIOLATIONS OF REGULATORY REQUIREMENTS OR STANDARDS FOR SAFE WORK WITH RADIATION AND RADIOACTIVE MATERIALS

Laboratory inspections and clinical reviews/audits are performed to ensure compliance with the applicable state and federal regulations and with the policies set forth in this manual. Violations of requirements will be addressed by the policies of this manual. This policy recognizes that specific circumstances and severity of violations call for different corrective or, if necessary, disciplinary actions.

This policy applies to all personnel using radiation-producing devices or radioactive materials at the University of Rochester under New York State Department of Health Radioactive Materials Licenses and to all personnel using radiation-producing devices or radioactive materials at off-site locations under the auspices of the University of Rochester’s radioactive materials license.

Policy

1. Violations may be noted at any time. Reporting of violations is not limited to formal inspections.

2. Violations will be classified as either major or minor. Major and minor violations are listed in this section. Two minor violations will be considered the equivalent of one major violation.

3. Violations may be corrected on the spot by the lab worker, if appropriate. Although such violations may be issued in these circumstances at the discretion of the RSO, the Permit Holder will be notified and a comment will be entered into the Permit Holder’s record.

4. Violations will be counted against the specific room or clinical area in which they were noted and will be charged against the permit under which that room is listed. Violations that take place in un-posted laboratory spaces will be charged against the permit holder responsible for the research being performed. Violations noted in common areas (corridors, equipment rooms, etc.), un-posted areas, or in laboratory space that does not belong to a radioactive materials user will be charged against the permit under which the radiation worker is listed or under which the radioactive materials were ordered, as appropriate.

5. All letters of violation must be approved by the RSO prior to issuing to the Permit Holder.

6. Upon issuance, the Permit Holder must provide a written response to the RSO within 10 working days. This written response must provide a brief description of circumstances causing the violation and note actions to be taken to prevent a recurrence of the violation. If the Permit Holder feels the violation was issued in
error or that there are mitigating factors, the violation may be contested to the RSO, who will decide whether or not to withdraw the violation. All communications with the Permit Holder will be retained in the Permit Holder’s file, where they will be available for review by the RSC upon request. Permit holders who do not provide a written response within 10 working days will be referred to the Chair of the RSC for further action.

7. Any Permit Holder receiving more than four major violations or the equivalent in major and minor violations in any six-month period will be subject to further review and possible disciplinary action. In these instances, the RSO will notify the user, conduct a review to determine root causes for violations, and request the user to respond in writing detailing corrective actions. The RSO will then refer the case to the chair of the RSC together with his recommendation for disposition. If the chair considers that actual or proposed corrective actions are adequate, no further action will be taken and the RSC will be informed of the case at the next regularly scheduled meeting of the RSC. If, however, the chair of the RSC considers that disciplinary action or suspension of the permit may be warranted, he will refer the case to either the entire RSC or appoint an ad hoc subcommittee to review the case and make a determination. If warranted, the permit holder may be requested to appear before the ad hoc subcommittee or the entire committee. Disciplinary actions will be intended to discipline the Permit Holder or the responsible party for repeated violations or for particularly flagrant or egregious violations of regulations or radiation safety practices. A list of possible corrective and disciplinary actions is included as an attachment to this policy.

8. In the case of particularly willful, flagrant, or egregious violations of regulatory requirements, radiological safety requirements, or health and safety practices, the RSO may immediately suspend a Radioactive Materials Permit and all work under it. Such suspensions will be immediately referred to the RSC Chair for concurrence. In the absence of concurrence, the Permit will be reinstated immediately. If the RSC Chair agrees with the suspension, a subcommittee of the RSC will be formed to determine subsequent actions to be taken. Examples of this would include but not be limited to the purposeful irradiation of personnel or dosimetry, use of radioactive materials to harm and individual, or to cause radioactive materials to be released into the environment in an uncontrolled/unpermitted manner.

9. Upon completion of all corrective or disciplinary actions, the RSO will perform a follow-up inspection of all spaces listed under the Permit in question to verify compliance with all required actions, regulations, and standards. Following this inspection, the RSO will recommend restoration of the Permit and resumption of radiological work.

10. Following Permit restoration, inspections will be performed monthly for a three-month probationary period, after which the normal (semiannual) inspection periodicity will resume.

11. Further violations noted during this probationary period will result in a recommendation for further corrective or disciplinary actions including loss of privileges to work with radioactive materials, and or termination.
12. Copies of all notices of major violations will be sent to appropriate Department Heads. Copies of correspondence resulting from an excessive number of violations will be sent to appropriate Department Heads and Deans. Copies of correspondence regarding Permit suspensions will be sent to appropriate Department Heads, Deans, and Vice Presidents.

**Major Violations**
1. Loss of security for radioactive materials in excess of 1 mCi aggregate activity
2. Eating, drinking, smoking, applying cosmetics or food storage in radiological posted laboratory space. This includes evidence of the listed items.
3. Use of radioactive materials by untrained personnel
4. Use of radioactive materials in an un-posted lab or room
5. Radioactive contamination in excess of 10,000 dpm/100 cm² in a posted area
6. Radioactive contamination in excess of 1000 dpm/100 cm² in any un-posted area
7. Unauthorized receipt, transfer, or shipping of radioactive materials
8. Loss of radioactive materials
9. Evidence of internal exposure of radioactive materials resulting from abnormal incidents
10. Failure to wear required radiation dosimetry
11. Radioactive materials in nonradioactive waste containers
12. Evidence of liquid radioactive waste disposal into laboratory sinks
13. Persons using radioactive materials while person or laboratory is under suspension
14. Unlabeled contaminated laboratory equipment
15. Failure to wear proper personal protective equipment (lab coat, gloves, etc.)
16. Failure to participate in required bioassay programs (if appropriate)
17. Failure to perform and document weekly radioactive contamination surveys during weeks in which radioactive materials were used
18. Pipetting by mouth of a radioisotope.
19. Purposeful irradiation of dosimetry
20. Purposeful irradiation of an individual
21. Use of radioactive material or devices to purposely harm an individual
22. Release or cause of release of unmonitored/unpermitted radiation to the environment.
23. Miss-application of radiation to a patient or staff resulting in unnecessary dose in excess of 1 mSv (100 mrem).

**Minor Violations**
1. Loss of security for any amount of radioactive materials less than 1 mCi aggregate activity
2. Presence of radioactive contamination more than 1,000 dpm/100 cm² and less than 10,000 dpm/100 cm² in a **posted** room
3. Presence of detectable radioactive contamination more than 200 dpm/100cm² and less than 1000 dpm/100 cm² in any **un-posted** area
4. Survey meter out of calibration or use of inoperable survey meter
5. Radioactive check source not available for contamination survey meter
6. Incorrect documentation of radioactive materials inventory (i.e., no decay corrections; total activity present in waste plus stock vials does not agree with activity received and not disposed; failure to return inventory verification form)
7. Improper waste segregation
8. Inadvertent dosimetry badge irradiation.
9. Fume hood air flow calibration out of date
10. Failure to post NY State information notice
11. Failure to remove or obliterate radiological symbols from empty containers in waste
12. Failure to report a radiological incident (spill, skin contamination, loss of radioactive material, etc.) to Radiation Safety within 2 hours of its occurrence
13. Failure to take appropriate immediate actions in the event of radiological emergencies such as spills or skin contamination incidents
14. Miss-application of radiation to a patient or staff resulting in unnecessary dose.
15. Any other activities that violate NY State regulations or the provisions of the referenced documents.

**Examples of Possible Recommended Corrective or Disciplinary Actions**

1. Temporary suspension of an individual’s authorization to use radioactive materials pending refresher training
2. Permanent suspension of a specific individual’s authorization to use radioactive materials at the University of Rochester
3. Mandatory refresher training for all personnel listed under a radioactive material permit
4. Suspension of authorization to order radioactive materials under a specific Permit for various periods of time up to two months
5. Suspension of Radioactive Materials Permit for periods of time up to one year
6. Complete revocation of Radioactive Materials Permit and the ability of specific individuals to use radioactive materials under any other permit at the University of Rochester
7. Financial penalty against the department.
8. Termination
SECTION 7: OCCUPATIONAL DOSE LIMITS

The New York Code of Rules and Regulations (NYCRR) Part 16 specifies dose limits for radiation workers and the general public. These dose limits do not apply to medical x-ray examinations or radiation therapy.

7.1 Occupational Dose Limits for Adults
NYSDOH dose limits are as follows:

1. The total effective dose equivalent being equal to 50 mSv (5 rem); or
   * the sum of the deep dose equivalent and the committed dose equivalent to any individual organ or tissue (other than the lens of the eye) being equal to 50 rem.

2. The annual limits to the lens of the eye, to the skin, and to the extremities are
   * an eye dose equivalent of 150 mSv (15 rem), and
   * a shallow dose equivalent of 500 mGy (50 rad) to the skin or to any extremity.

University of Rochester limits may only be exceeded with the approval of the RSO and the Chairman of the Radiation Safety Oversight Committee. Requests for the extensions must be made in writing and are granted in increments of 10 mSv (1 rem) at a time. (See letter of July 1st, 2013 from the Chairman of Radiology, the RSO and LLE Senior Scientist.

The determination of deep, shallow, and internal dose is estimated by procedures presented in 10 NYCRR Part 16.

These limits must be reduced by the amount of the occupational dose that an employee may have received at a previous place of employment.

7.2 Radiation Exposure During Pregnancy

The dose to an embryo/fetus during the entire pregnancy, due to occupational exposure of a declared pregnant woman, must not exceed 5 mSv (500 mrem) with a UR goal of 200 mrem or 2 mSv. When a woman voluntarily declares pregnancy, in writing, Radiation Safety must review past exposure history and provide exposure counseling. When necessary, the pregnant worker’s supervisor may have to adjust working conditions so as to avoid a monthly dose rate of greater than 0.5 mSv (50 mrem) with a UR goal of 20 mrem or 0.2 mSv. Declaration of pregnancy is a voluntary act and may be withdrawn at any time.

It is the policy of this institution to assure that the unborn children of its employees be protected to the greatest extent possible from possibly harmful effects of the work environment. When a worker becomes pregnant, special provisions may be considered on an individual basis. The RSO should be consulted for more information and guidance. Also, see Appendix C, NRC Regulatory Guide 8.13 and University of Rochester Radiation Safety Policy and Forms, for additional information. These documents are located at the RSU’s office in G-8842.
7.3 Occupational Dose Limits for Minors

The annual occupational dose limits for minors is 10% of the annual occupational dose limits specified for adult workers in Section 7.1.

7.4 Determination of Internal Doses

The Annual Limit on Intake (ALI) is the basis for estimating the dose of radiation from internally deposited radionuclides. Briefly, an estimate is made of the amount of a given radionuclide in the employee’s body by testing urine, or directly monitoring a person with a radiation detector. This process is called bioassay. Based on the bioassay results, a dose is determined by a RSU Health Physicist. All bioassay results must be reviewed by the RSO.

The Derived Air Concentration (DAC) is used to determine the committed effective dose equivalent in cases where people are exposed to contaminated atmospheres. These are specified in 10 NYCRR 16.

In cases where procedures may result in the production of a radioactive atmosphere, provision may be made to apply respiratory protective measures. These are outlined in 10 NYCRR 16.26. The RSO will consider these conditions on a case-by-case basis, using the appropriate measures mentioned in 10 NYCRR 16.26.

In the rare event of an ingestion of a radionuclide, methods will be used, employing the ALI, to determine the dose received.

Requirements for bioassays are listed on each Principal Investigator’s permit as a condition of the permit. Authorized Users are required to follow all bioassay conditions listed on permits. At a minimum those using more than 1 mCi of iodine or 80 mCi of tritium require periodic bioassays.

7.5 Radiation Dose Limits for Individual Members of the Public

(1) The dose in any area outside of a controlled area shall not exceed 0.02 mSv (2 mrem) in any one hour.

(2) The total effective dose equivalent to individual members of the public from the licensed operation does not exceed 0.1 rem (1 mSv) in a year, exclusive of the dose contributions from background radiation, from any administration the individual has received, from exposure to individuals administered radioactive material and released from voluntary participation in medical research programs, and from the licensee's disposal of radioactive material into sanitary sewerage in accordance with regulation, and

(3) The dose in any unrestricted area from external sources, exclusive of the dose contributions from patients administered radioactive material and released in accordance with regulation, does not exceed 0.002 rem (0.02 mSv) in any one hour.

7.6 Radiation Dose Calculations for Pregnant Patients Exposed to Diagnostic or Therapeutic Medical Procedures Utilizing Ionizing Radiation

In the event a pregnant patient receives diagnostic x-rays, CT scans, fluoroscopy procedures or other medical procedures that may expose the developing fetus (an area defined as
between the top of the chest and above the knees) to ionizing radiation, the following actions must be taken:
The medical department performing the procedures must inform the RSO immediately upon learning of the potential fetal exposure.
The medical department must provide the RSO with all relevant information via the Fetal Dose Estimation Information Sheet (RSU Form 025) including:
- The date of the procedure(s);
- Patient Medical Record Number;
- The estimated date of conception;
- Body Part;
- The tube voltage, current, and fluoroscopy time of exposure for all x-ray, CT, and fluoroscopy procedures;
- Air Kerma (AK) in units of mGy if fluoroscopy procedure;
- The slice thickness, number of slices, and location of the uterus for all CT procedures;

The RSO or competent individual will calculate an estimated fetal radiation dose based on the information provided, using standard and accepted references. If the results exceed 0.1 Gy (10 Rad), another independent calculation will be performed by a Certified Health Physicist or equivalent. This information will be provided to the appropriate medical department and to the appropriate primary care physician or obstetrician. If the results exceed 0.25 Gy (25 Rad) a discussion concerning the risk to the fetus must occur between the RSO and the overseeing physician.

The RSO may not make any medical recommendations regarding the fetal radiation exposure because the RSO is not a qualified physician. However, the RSO can and should provide the woman’s physicians with appropriate medical guidance from accepted, standard references if such guidance exists. If such guidance is cited, copies of the appropriate referenced materials should be provided along with the fetal dose estimate.

7.7 Reportable Dose Limits from Medical Exams

All fluoroscopic examinations with a total air KERMA \( \geq 2 \text{ Gy} \) must be reported in RL Solutions.

All fluoroscopic examinations with a total air KERMA \( \geq 5 \text{ Gy} \) must be reported to the University RSO.

If the fluoroscopic unit does not report air KERMA then all examinations from that unit that have a total fluoroscopic time \( > 60 \text{ minutes} \) must be reported to the University RSO.

See Appendix B for references.
See Appendix C for Radiation Exposure Policy.
SECTION 8: PERSONNEL MONITORING

8.1 Dosimeter Requirements
According to NRC 10 CFR Part 20.1502 and NY State Department of Health regulation 10 NYCRR Part 16.11, personnel are required to wear radiation dosimetry if the personnel meet the following conditions:

A. Are likely to receive a radiation dose in excess of 10% of the Occupational Limit of 5mSv (500 mrem) per year or 1.25 mSv (125 mrem) in any quarter of one year.

B. Are entering a High Radiation Area whereas the radiation field is greater than 1 mSv/hr (100 mrem/hr) at 30 cm (approximately 12 inches) from the source of radiation.

C. A declared pregnant women likely to receive a dose in excess of 0.5 mSv (50 mrem) per year.

NOTE: These conditions are generally applicable if you work with radiation generating equipment such as X-ray machines, fluoroscopy machines, computed tomography scanners, irradiators or many radionuclides.

Dosimeters are not required for elements that emit beta radiation of such low energy that it cannot be detected by a dosimeter, e.g., H-3, C-14; S-35; Ca-45. Radiation workers may request to be issued a dosimeter even if this is not required. Such requests must be approved by the Permit Holder before any such dosimeter will be issued.

The University contracts with a vendor dosimeter service that is accredited under National Voluntary Laboratory Accreditation Program (NVLAP), a voluntary program for determining that a dosimetry service meets American National Standards Institute standards.

8.2 How to Obtain a Dosimeter
Employees needing dosimetry must first complete required training. For specific training guidelines, contact Radiation Safety. Then, a “Radiation Worker Information Form” (HO Form 5C/5C-T) must be completed and submitted to RSU. A University account number is necessary so that the dosimeter charge can be properly billed. A current charge schedule is available through the RSU web page at the following URL:

http://Intranet.urmc.rochester.edu/RadiationSafety.

For employees who have worked with and/or around radioactive material in the past, a request for dose history will be made by the RSU.

8.3 Wearing a Dosimeter
Dosimeters are to be clipped to an article of clothing between the waist and shoulder level at the front of the torso (unless otherwise instructed for the type of dosimeter issued). This location should be the area where the body is receiving the greatest exposure. If a protective apron is used, the dosimeter must be worn at the collar level outside the apron. An individual monitoring device used for monitoring the eye dose equivalent shall be located at the neck outside any protective apron worn by the individual, or at an unshielded location closer to the eye.
An individual monitoring device used for monitoring the dose to an embryo/fetus of a declared pregnant woman, shall be located at the waist under any protective apron worn by the woman. Arrangements may be made for another dosimeter to be worn under the apron. When only one individual monitoring device is used and it is located at the neck outside the protective apron, the reported deep dose equivalent value multiplied by 0.3 shall be the effective dose equivalent for the external radiation. When two individual monitoring devices are worn, one worn under the protective apron at the waist and the other worn outside the protective apron at the neck, the effective dose equivalent for external radiation shall be assigned the value of the sum of the deep dose equivalent reported for the individual monitoring device located at the waist under the protective apron multiplied by 1.5 and the deep dose equivalent report for the individual monitoring device located at the neck outside the protective apron multiplied by 0.04.

8.4 Proper Use of Dosimeters

Dosimeters are issued in accordance with 10 NYCRR 16; therefore, dosimeters are a legal document, and as such, they must not be tampered with in any manner. Erroneous exposure readings caused by deliberate exposure will result in investigation by the RSU and possibly the Department of Health and remain part of a person’s permanent exposure record.

Dosimeters issued by the University are to be used to measure occupational exposure at the University of Rochester only. They may not be used at any other institution. They must not be worn while receiving medical or dental x rays. Dosimeters may be worn home or kept in a car. No person is permitted to wear another’s dosimeter at any time for any reason. No person may purposely irradiation their badge to place a false reading on it.

8.5 Misuse of Dosimeter

A dosimeter that has been assigned to an individual may not be used by any other person. The participant number is a lifetime assignment and is not transferable to another person. If a dosimeter is lost or misplaced, a temporary dosimeter will be issued upon request. Any abnormal occurrence should be reported, and a new dosimeter should be issued if the old dosimeter is damaged or misused in any way. Dosimeters should be kept away from radiation when not in use. Control dosimeters should be used only where the unused dosimeters are kept. Dosimeters should not be left on lab coats or shield aprons where they could be accidentally contaminated with radioactivity, or left in rooms where they could be exposed to radiation. Dosimeters must not be purposefully irradiated to place an exposure on them in order to create a false dose.

8.6 Responsibility for Use of Dosimeters

It must be the responsibility of all individuals and supervisors to wear personnel-monitoring equipment in accordance with the above policies and procedures. Supervisors must ensure compliance. It is the responsibility of all persons and supervisors to cooperate with Radiation Safety in an investigation of exposures when required. It is the responsibility of each individual to return his/her personnel-monitoring equipment to the appropriate place at the end of each work day. If a dosimeter is lost or damaged, Radiation Safety must be notified promptly.
If an investigator decides that dosimeters are no longer needed, it is his/her responsibility to notify Radiation Safety in writing. If Radiation Safety agrees, the dosimeter will be terminated promptly. If an employee terminates or transfers, Radiation Safety must be notified, in writing, by the investigator before the dosimeter is withdrawn.

8.7 Periodic Exchange

Each group or series will have a designated person to handle the periodic exchange of dosimeters. Each exchange period the dosimeter packets are mailed by intramural mail to the designated individual.

This person will exchange the dosimeters and return the previous period’s dosimeters by the return date. The dosimeters are to be exchanged on the date of the new dosimeters or as near as possible to that date. Return the dosimeters by intramural mail if they will arrive by the return date; otherwise, hand deliver to Radiation Safety.

Recent regulations require that when a dosimeter is not returned, Radiation Safety must conduct an investigation and make an estimate of the dose received by the individual to whom the dosimeter was assigned. This requires extra, and often unnecessary, effort on the part of the Radiation Safety staff. To reduce this extra effort and expense, Radiation Safety has introduced a fee for late dosimeters and another fee for missing dosimeters.

8.8 Exposure Results

Exposure results are received from the dosimeter company approximately two weeks after the dosimeters are returned. This is usually the following month. The reports are mailed to each group upon receipt. If you have any questions concerning the reports, contact Radiation Safety. The reports will be posted or made available for review by your dosimeter administrator so that each individual is aware of his/her dose.

Any individual may also obtain his/her dose record by sending a written request to Radiation Safety.

8.9 Radiation Dosimetry Reports

Doses are reported in units of mrem. The minimum dose that is detectable on a dosimeter is 1 mrem for X-rays and gamma rays and about 10 mrem for neutrons and energetic beta particles. If the dose results are not measurable, the dose is recorded as 0, *, or m). State regulations require that records be kept of the deep dose equivalent to the whole body, eye dose equivalent, shallow dose equivalent to the skin, and shallow dose equivalent to the extremities. Various notes explaining the reports are found on the reverse side of the dosimetry report. If clarification is needed, contact Radiation Safety (ext. 5-3781).

In addition to records of the external dose equivalent, records must be kept of all ingested or inhaled radioactivity. From this information the committed effective dose equivalent will be determined, and added appropriately to the external dose as required by 10 NYCRR 16. Examples of internal dose measurements include bioassay of urine or thyroid gland.

8.10 Notification and Investigation of Exposures

The annual dose limit is a total effective dose equivalent equal to 0.02 Sv (2 rem). This corresponds to 1.65 mSv (165 mrem) per monthly or dosimeter change period. In
compliance with ALARA principles, two local University of Rochester monthly and quarterly limits have been established by the RSC:

<table>
<thead>
<tr>
<th>Exposed Organ or Tissue</th>
<th>Level I (Notification)</th>
<th>Level II (Investigation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total effective dose equivalent</td>
<td>1 mSv or 100 mrem</td>
<td>1.65 mSv or 165 mrem</td>
</tr>
<tr>
<td>Lens of the eye</td>
<td>1 mSv or 100 mrem</td>
<td>1.65 mSv or 165 mrem</td>
</tr>
<tr>
<td>Skin and extremities</td>
<td>10 mSv or 1000 mrem</td>
<td>16.5 mSv or 1650 mrem</td>
</tr>
</tbody>
</table>

Employees will receive a letter when monthly or quarterly exposures exceed Level I. Any dosimeter reading that exceeds the investigation level (Level II) will be investigated by the RSO. Subsequent exposures to ionizing radiation must be reduced.

**8.11 Other Dosimetry Services**

Other types of dosimeters are available for special needs. Ring dosimeters (TLD) and wrist dosimeters are available for monitoring fast neutron dose. Routine analysis for internal exposure to radioactive material is available from the RSU for users of tritium, iodine-125, and iodine-131. Other radionuclides may be monitored by special arrangement with Radiation Safety.

Electronic dosimeters are available in areas where there is a high probability of exposure to radiation that may challenge monthly limits. These areas include CT scanners, fluoroscopy rooms and similar areas where scatter radiation is present in large quantities.

**8.12 Visitors**

The term “visitor” is used to designate all persons for whom personnel-monitoring equipment is not provided on a routine basis, including employees, students, and consultants, as well as visitors from outside.

If visitors, with the exception of building contractor personnel, expect to be in a radiation area from time to time for a period of four consecutive weeks or more, Radiation Safety must be notified by the Department or Division concerned so that regularly assigned personnel-monitoring equipment can be issued, if required. This service will be furnished for an indefinite period until canceled. The Department or Division concerned must notify Radiation Safety of the departure date when determined. Appropriate radiation safety training will be required for visitors prior to allowing radiation exposures.

Employees of building contractors are expected to use visitor badges when necessary, even though they may be expected to stay for several months. Contractors may wear their own dosimetry with the concurrence of Radiation Safety.
SECTION 9: REQUIREMENTS FOR POSTING/LABELING LABS USING RADIOACTIVE MATERIAL

9.1 Radioactive Material Areas: Posting and Labeling

1. A sign or label with the words “CAUTION-RADIOACTIVE MATERIAL” must be placed on each door, refrigerator, or storage locker where radioactive materials exceeding 10 times the quantities specified in Appendix A, Table 9 of 10 NYCRR Part 16 are used or stored. The sign or label will also be affixed to storage and waste containers, contaminated waste cans, hot sinks, hoods, and work areas. In the event multiple nuclides are present, the “sum of the ratios” must not exceed a value of 1. Values for the most commonly used nuclides are included in Section 18 of this manual.

2. Laboratory equipment and containers, including beakers, flasks and test tubes, pipettes, centrifuge, and so forth, must be labeled with a radiation symbol.

3. Containers holding radioactive materials must be labeled with the radiation symbol, the words “Caution, Radioactive Materials,” and the isotope(s) and activity contained within.

4. Exemptions to these labeling rules include
   * containers with a minor amount of radioactive material as defined in 10 NYCRR Part 16, Appendix A (the amounts of radioactivity considered minor are included in Section 18 of this manual);
   * laboratory containers, such as beakers, flasks, and test tubes, used transiently in laboratory procedures (i.e., for a period of a few hours) in the presence of an authorized user; or
   * containers in transport must be packaged and labeled in accordance with the regulations of the U.S. Department of Transportation.

5. Only RSU or staff under the direct instruction of RSU may remove Radioactive Material postings.

9.2 Empty Containers

Empty containers that are free of contamination and are to be discarded must have all radioactive materials labels, all radiation symbols, and all markings related to radiation or radioactive materials removed prior to disposal. If this is not possible, Radiation Safety should be contacted for assistance.

9.3 Other Postings

Other postings must be established as required by 10 NYCRR Part 16 to mark radiation areas, high-radiation areas, airborne radioactivity areas, and/or controlled surface contamination areas (CSCA). A CSCA is any area in which loose surface contamination levels exceed 1000 dpm/100 cm. Access to controlled surface contamination areas must be restricted by a physical barrier posted with a sign noting “Controlled Surface Contamination Area, Do Not Enter.”
9.4 Misuse of Caution Signs

Labels and signs required in this section must not be used for any purpose other than to warn against a radiation hazard.

SECTION 10: CONTAMINATION AND RADIATION SURVEYS OF LABORATORIES USING RADIOACTIVE MATERIALS

All laboratories where radionuclides are used as unsealed sources must be surveyed by laboratory personnel after every use of radioactive materials and every week when radioactive materials are used. Radiation Safety, Nuclear Medicine, and Nuclear Cardiology must be surveyed on a weekly basis. Post-work surveys should concentrate on the areas in which radioactive materials were used; these surveys need not be documented. Weekly surveys should include a sampling of areas from throughout the laboratory and must be documented. Survey reports must be retained by the laboratory for a period of three years.

All radiological surveys must be performed in accordance with the appropriate Standard Operating Procedure, a copy of which is provided to every Permit Holder and is maintained by the RSU. Survey results will be recorded in units of disintegrations per minute (DPM) unless the survey is performed with an ion chamber, micro-Sievert meter, micro-R meter, or other dose-rate instrument.

As part of the laboratory inspection program, the RSU will perform a survey of all laboratories semiannually. These surveys will be recorded, and a copy will be returned to the laboratory within one week of completing the inspection.

Contamination surveys may be performed with a hand-held instrument if the instrument used has a detection efficiency of 10% or greater for the nuclide(s) in use. Such nuclides are typically P-32 and I-125. Surveys for other nuclides must be performed by taking smear wipes of an area of 100 cm² and counting them with a liquid scintillation counter. These survey results will be recorded as dpm/100 cm². Such nuclides include H-3, C-14, and S-35.

Routine surveys consist of measurements of

- contamination levels of stored radioactive material (dpm),
- general area radiation levels in laboratories (dpm or mrem), and
- airborne radiation levels either in laboratories or hoods or in effluent streams discharged to the environment (μCi/ml).

Results of such surveys are recorded on a floor plan in their exact locations.

Small amounts of contamination will be unavoidable at times, but the degree of such contamination should be kept as low as possible. Loose contamination on exposed surface, such as bench tops and floors, must be removed as soon as possible. All loose surface contamination must be reduced to the lowest practical levels; however, cost and time to decontaminate must be considered. **Radiation Safety must be consulted before**
releasing contaminated materials or facilities for unrestricted use. Maximum regulatory limits for removable contamination are listed in the following table:

<table>
<thead>
<tr>
<th>Application</th>
<th>Alpha (dpm/100 cm²)</th>
<th>Beta/Gamma¹</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>Removable</td>
</tr>
<tr>
<td><strong>Controlled Area</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basic Guide</td>
<td>25,000 max</td>
<td>500</td>
</tr>
<tr>
<td></td>
<td>5,000 avg.</td>
<td>5 (0.5)</td>
</tr>
<tr>
<td>Clean Area</td>
<td>1,000</td>
<td>100</td>
</tr>
<tr>
<td><strong>Non-controlled Area</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Skin, personal clothing</td>
<td>500</td>
<td>ND²</td>
</tr>
<tr>
<td>Release of material or facilities</td>
<td>2,500 max</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>500 avg.</td>
<td></td>
</tr>
</tbody>
</table>

¹ Measured at 1 cm from the surface.
² ND means non-detectable.

Reference NYS Part 16

Also see Ref. US Regulatory Commission Regulatory Guide 8.24 Revision 2, 2012
SECTION 11: GUIDELINES FOR THE SAFE USE OF RADIOACTIVE MATERIAL

Good radiological work practices can encompass a wide variety of practices that may vary in some ways between laboratories. The following practices are general in nature and apply to most research and medical uses of radioactive materials:

1. Prior to performing operations with quantities of radioactive material that may produce significant external or internal exposure, attention must be given by the user to precautionary measures including the use of remote handling devices, hoods, shielding, etc. The RSU must be consulted before beginning any new use of radioactive material.

2. There must be no eating, smoking, drinking, applying cosmetics, or preparation of food in any laboratory posted with the radiation or radioactive material symbol or in any location where unsealed sources of radioactive materials are used or stored.

3. No food, drink, or personal effects will be stored with radioactive material.

4. Pipetting of radioactive solutions by mouth is prohibited.

5. Segregate and label all laboratory equipment (e.g., pipetting devices, centrifuges, etc.) used with radioactive materials from those used with nonradioactive solutions.

6. Lab coats and disposable gloves must be worn during operations involving the handling of unsealed sources of radioactive material. The lab coat and gloves should be surveyed for radioactive contamination before leaving the laboratory. Shorts, skirts, open-toed shoes, and other articles of clothing that expose bare skin to possible radioactive contamination may not be worn while working with radioactive materials.

7. Care must be taken such that other items (e.g., pens, pencils, notebooks, door knobs, telephones, etc.) are not handled with gloves used while working with radioactive materials.

8. Work that may result in contamination of work surfaces must be done on plastic-backed absorbent paper or other materials that are approved by the RSU. Trays made of impervious materials (e.g., stainless steel, porcelain-coated, etc.) and lined with absorbent paper provide excellent work arrangements to help prevent the spread of contamination.

9. Work surfaces and personnel must be monitored after working with radioactive materials.

10. Objects and equipment that may have been contaminated with radioactive material must be surveyed and demonstrated to be free of contamination prior to their removal from a laboratory. Contaminated items must be controlled and decontaminated as soon as practical.

11. Radiation dosimetry must be worn (if issued) at all times when working with radioactive materials. Dosimeters should be kept away from radioactive materials.
when not in use. Section 8 of this manual describes dosimetry policies in greater detail.

12. Radioactive material should be transported in containers that can be sealed to minimize the possibility of causing a spill of radioactive materials. Containers of radioactive liquids being transported must be capped or sealed and transported in secondary containers to minimize the potential for a spill.

13. Personnel working with radioactive materials should avoid working alone so that, in the event of a radiological emergency, a person is available to provide assistance.

14. Each individual is responsible for contacting the RSU of any radiological spills, skin contamination, ingestion or inhalation of radioactive materials, or other emergencies.

15. All portable survey instruments must be calibrated annually. Principal Investigators are responsible for ensuring meters in their possession are calibrated before use.

16. Principal Investigators are responsible for an inventory of all radionuclides under their permit and present in working spaces assigned to them.

17. State laws require that warning signs be placed on all doors of laboratories where licensable quantities of radionuclides are being used.

18. Radioactive material or waste must be secured from unauthorized removal at all times when not in use.

19. All radioactive waste material must be collected and packaged as described in Section 15 of this manual.

20. Use of more than 1 mCi of any iodine isotope in the laboratory requires the worker to come to the RSU for a thyroid bioassay between 24 and 72 hours after use. The use of more than 80 mCi of tritium requires the worker to submit a urine sample to the RSU for bioassay within one week.

21. Wear gloves when handling non-coated lead shielding
SECTION 12: SEALED AND UNSEALED RADIOACTIVE SOURCES

12.1 Location
1. Anyone requiring sealed sources must obtain permission for their use from the RSO.
2. All sealed sources must be registered with the RSU.
3. Any radioactive material that is not permanently sealed is considered to be an unsealed source. The use of these radionuclides is restricted to qualified experimenters and technicians only.

12.2 Handling
1. A radioactive material label must be attached to each sealed source. The label information must state the radionuclide, activity, and date of assay. Lettering must be legible from a safe distance. Whenever possible, the source capsule itself should have a mark identifying the radionuclide engraved or etched on it. Unsealed sources should be stored in containers that have the same information attached to the container.
2. Remote handling equipment is required for sources having an exposure rate of more than 100 mrem per hour at 1 meter and must be used at all times. Movement of sources from the shielded position to the calibration position should be accomplished by mechanical manipulators or other remote control methods; however, only methods of transfer that do not subject the source to repeated shocks, vibration, or pressure should be used.
3. All sealed sources must be leak-tested by the RSU for possible surface contamination prior to initial use. Subsequent tests must be performed at least once every six months on beta-gamma sources containing greater than 3.7E+6 Bq (100 µCi) and every three months for alpha-emitting sources of greater than 3.7E+5 Bq (10 µCi.) (See 10 NYCRR 16.10 (a) (4) for specific requirements and exemptions.)

12.3 Transport of Sources
1. External Transport
   a. If sources are to be transported from one campus to another over public highways, contact the RSU to arrange for proper packaging, survey, and manifesting to accompany the shipment.
   b. All sealed and unsealed sources of radioactivity must be transported by RSU personnel in the absence of written permission to do otherwise.
2. **Internal Transport**
   a. Transport of sources within a building must be accomplished with appropriate shielded containers. The shield design must be adequate to reduce personnel exposure as much as practicable. The container must be labeled with the “Caution Radioactive Material” label, the radionuclide, date, and amount. Call the RSU if assistance is needed in selecting a proper shield,
   b. In cases where the radiation level cannot be shielded below 5 mR/hr at 30 cm, the container must have wheels or be placed on a cart. The cart or device must be posted with a “Caution Radiation Area” sign and handled to minimize exposure.
   c. Sources must not be left unattended in hallways and must be secured against unauthorized removal at all times while in storage.
   d. Only persons who have completed the Radiation Safety training program at the University may transport sources. In most cases, the person must be equipped with a monitoring device such as a dosimeter.

12.4 **Sealed Source Irradiators**
   1. Each sealed source teletherapy facility and gamma irradiator must have written procedures for use and control of the source. Only trained and qualified operators may use an irradiator.
   2. All irradiators must be surveyed by the RSU upon installation and when any changes are made such as source replacement or structural modifications.
   3. All interlocks, on–off beam control mechanisms, and safety and warning devices must be checked by the RSU at least once every six months. Any failure of a safety system will result in suspension of operations for the source device until repairs have been made.
   4. Emergency procedures must be posted on or near the irradiators’ control panel.
   5. The University’s Radioactive Material License and 10 NYCRR Part 16 list specific requirements for the irradiators. Users should consult with Radiation Safety for information on these requirements.

12.5 **Storage of Radioactive Materials**
Radioactive materials stored in an unrestricted area must be secured against unauthorized removal from the place of storage:
   1. Access to radioactive materials must be restricted to authorized radiation workers.
   2. Methods of restricting access include, but are not limited to, the following:
      a. locking laboratory doors when no personnel are present,
      b. locking a corridor containing several rooms, and
      c. placing radioactive stock vials in a locked refrigerator or a lockbox to prevent removal.

**Note:** Radioactive material that have not be in use for a period of 24 months or greater should be disposed of per NYS Dept. of Labor. Contact RSU for guidance.
SECTION 13: PROCEDURE FOR OBTAINING RADIONUCLIDES

13.1 Approval to Use Radioactive Material
Principle Investigator: Must apply for a permit through the Radiation Safety Unit by completing Part A, Part B, and a 5C form, in addition to supplying a copy of his/her CV. All forms are available through the RSU. This permit must then be approved by a subcommittee of the RSC.

Radiation Worker: Must take appropriate training, pass the required exam, and apply for a dosimeter, if needed, using the 5C/5C-T form.

13.2 Orders for Radioactive Material
All radioactive material must be ordered through the RSU using a 312 University requisition, with the exception of unit doses of radioactive materials ordered by the Nuclear Medicine and Nuclear Cardiology departments. Only qualified personnel operating under a valid permit are allowed to initiate orders for radioactive material. Requisitions must be submitted to the RSU by 2 PM, Monday—Friday. Shipping schedules for free shipping days can be obtained from the RSU web page at the following URL:

http://Intranet.urmc.rochester.edu/RadiationSafety.

1. Information required on a 312 requisition includes name of vendor, room to which the permit material will be delivered, catalog number, quantity (# of isotopes wanted), measure (amount of Bq (mCi) wanted), complete description of material, name of end user (listed under “Requested by...”), department, phone number, box number, signature of permit holder (or assigned approver), printed name of permit holder, and an account number to charge.

2. The RSU will authorize each order for radioactive materials by ensuring that the requested materials and quantities do not exceed possession limits assigned to that permit. If the permit limit is exceeded, the order will not be placed and the department will be notified.

13.3 Receipt of Radioactive Materials
1. All radioactive material will be delivered to the RSU between the hours of 8:00 a.m. and 4:30 p.m., unless special arrangements are made.

2. Upon arrival, all packages are surveyed and inspected by the RSU.

3. All orders will be delivered to the appropriate lab by a member of the RSU. The person receiving the material must be an authorized lab representative and must sign a receipt log.

4. It is required that packages be inspected immediately (by the lab) upon receipt to ensure completeness of the order. The package should be opened using due caution to contain potential internal packing contamination (see Sect. 14, Procedures for Opening Packages). The shipment is then entered in the lab’s log book.

5. Only the RSU may procure radioactive material, even if the material is offered to an authorized user at no cost. Exceptions may be made by special arrangement with
Radiation Safety, such as for clinical use. If radioactive material is obtained by other means, however, Radiation Safety is to be notified immediately. If radioactive material is transferred to another laboratory or to another investigator, Radiation Safety must be notified prior to the transfer.

13.4 Radioactive Material with an Atomic Number Greater than 83
The University’s Radioactive Materials License authorizes the possession, use, and transport of any radioactive material with an atomic number greater than 83 (Bismuth); however, the authorized quantities are very small. This includes any radioactive material in sealed sources, unsealed sources, or fabricated as targets. Possession, use, or transport of any such radioactive material must be made by special arrangement through Radiation Safety. This procedure may require a license amendment, so researchers should allow at least a month to accomplish the necessary arrangements.
SECTION 14: OPENING RADIONUCLIDE CONTAINERS

1. Radioactive packages are received by the RSU, which will perform all required radiological surveys and inspections in accordance with the requirements of 10 NYCRR Part 16 and Radiation Guide 10.1, Revision 2.

2. Proper personal protective equipment, including impermeable gloves and a laboratory coat, should be used when handling radioactive material containers. In addition, there should be no bare skin exposed that could become inadvertently contaminated; therefore, shorts, skirts, and open-toed shoes may not be worn.

3. Special handling or opening procedures supplied by the vendor should be followed.

4. Stock vials and other radioactive materials containers must be opened only in properly posted rooms.

5. Extreme caution should be used when opening the inner vial containing the radioisotope. Personnel and area monitoring for possible contamination should be performed after all use or handling of radioactive materials.

6. The container usually includes the liner, shield, absorbent materials, and isotope container, which may be contaminated. Container material should be disposed of as radioactive waste if found by appropriate monitoring techniques to be contaminated. (Any container placed in regular trash must be surveyed for contamination and have all radioactive labels removed or obliterated.)

7. Problems should be reported to Radiation Safety at ext. 5-3781.
SECTION 15: RADIOACTIVE WASTE DISPOSAL

The treatment and ultimate disposal of radioactive wastes depend on many factors and are strictly regulated by both the New York State Department of Health and Department of Environmental Conservation. Regardless of the method of disposal, written records must demonstrate that disposal amounts are reasonably balanced against the acquired amounts. For these reasons, and to alleviate possible hazards involved in handling radioactive waste, disposal plans must be prepared before a research program is initiated. Please see RSU website for more details.

15.1 General Rules

1. Minimization of radioactive and mixed waste is a regulatory requirement and an important University goal to minimize risk and reduce costs. An important step in volume reduction is to segregate radioactive waste from nonradioactive waste.

2. Packages that present added hazards may require sorting before the RSU will accept them. Such hazards include the presence of sharps (broken glass, hypodermic needles, razor blades, etc.), hazardous chemicals, and overly filled liquid waste containers.

3. All dry solid radioactive waste must be separated into long half-life and short half-life waste categories. Waste containers are provided for solid waste disposal by the RSU. No liquids are accepted with the solid waste. Short-lived radionuclides are those that may be stored for radioactive decay in accordance with the University of Rochester’s radioactive materials license (half-lives less than 90 days).

4. Animal carcasses containing radioactivity must be individually packaged, regardless of the size of the animal, and each package must be tagged securely with a three-copy waste tag indicating the isotope in µCi/gm for the weight of the radioactive carcasses.

5. All liquid waste must be accumulated in containers identified with a three-copy waste tag and contained by a secondary containment. The container should not be filled to more than three-quarters full.

6. Scintillation vials should be stored in separate containers.

7. Tags for labeling radioactive waste for disposal are available at no charge from the RSU. The label for all radioactive waste must include
   a. date,
   b. radionuclide(s),
   c. decay-corrected activity in µCi or mCi for each radionuclide,
   d. ship code number,
   e. name of the PI and lab room number, and
   f. any secondary hazard that may exist (e.g., hazardous chemicals).

8. Needles, syringes, and sharps of any kind must be collected in a sharps container, not in the containers provided by the RSU.
9. Disposal of any high-activity waste will be handled on an individual basis. Contact the RSU to make arrangements.

10. All waste disposals must be recorded in the radioisotope log book. The amounts recorded should agree with the amount written on the waste tag.

11. All radioactive identification labels must be defaced or removed from radioactive containers and packages before disposal in radioactive waste containers. Containers and material that are not contaminated should be discarded as nonradioactive waste.

15.2 Radioactive Waste Storage, Processing, and Disposal

1. Short-lived solid radioactive waste (half-lives less than 90 days) may be stored for radioactive decay and subsequently disposed of without regard to the radioactivity content. These wastes must be processed and then stored in the RSU’s waste processing and storage areas while awaiting disposal.

2. Long-lived solid radioactive wastes must be sent for off-site treatment and land burial. They must be processed prior to shipment and then stored in the RSU’s waste processing and storage areas.

3. Low-level liquid radioactive wastes that meet sewage discharge limits may be disposed of into the sanitary sewer system so long as they also meet chemical disposal criteria. All such disposals must be performed and recorded by the RSU and reported to the NY Department of Environmental Conservation as required by regulations.

4. Liquid radioactive wastes that cannot be disposed of into the sanitary sewer system must be transferred to the RSU for processing for radioactive decay or off-site disposal, depending on the half-life of the nuclide(s) present.

5. Solid waste may be processed on-site by the RSU compaction and separation of the solids and liquids.

6. Animal carcasses and liquid scintillation fluid containing less than 0.05 μCi per ml may be disposed of without regard to the radioactivity present by RSU. Such wastes are referred to as “de minimus” waste.
SECTION 16: ANIMALS CONTAINING RADIOACTIVITY

1. No research involving animals may be conducted without receiving approval from the University Committee on Animal Research (UCAR).

2. All animals used for research purposes must be housed in the Vivarium except when their presence in the laboratory is required.

3. Injections of radioactive material into animals must be performed over absorbent paper. The person conducting the injections must wear protective gloves to minimize the possibility of skin contamination.

4. All cages housing animals injected with radioactive materials must be marked with the radiation symbol and a tag or label indicating the nuclide(s) and activity injected into each animal, the date(s) of injection, and the name of a contact person.

5. Prior to commencing any research involving the injection of radioactive materials into animals, the researcher must submit a Form 5B to Radiation Safety for approval. The proposed completion date of these experiments must be included on the form.

6. The researcher will be provided with a temporary door sign that must be hung on the door to any rooms in which radioactive animals are housed. This sign must remain on the door until the room has been cleared by the RSU after completion of the experiment and removal of the animals.

7. It may be required to collect all animal bedding and excreta. This determination will be made by the RSU. If such collection is necessary, radioactive waste containers will be provided to the investigator who is responsible for filling labeling (see Section 15).

8. All animals must be given to Radiation Safety for proper disposal after they have been sacrificed. They must be kept frozen until collected by or delivered to the RSU.
SECTION 17: PROCEDURES IN CASE OF RADIOLOGICAL INCIDENTS

17.1 Incident Reporting
All incidents involving the use of radiation-producing devices or radioactive material, no matter how minor the accident must be reported immediately to the RSU (ext. 5-3781). After hours and during weekends or holidays, call Security (ext. 13). The notification and reporting of incidents is mandatory according to Paragraph 20.403 of the Code of Federal Regulations and 10 NYCRR 16.15.

17.2 Radiological Incidents
A radiological incident is any event (defined below) involving radioactive contamination, high radiation levels, or the loss of radioactive materials. All radiological incidents must be reported immediately to Radiation Safety (ext. 5-3781) during working hours and to Security (ext. 13) after hours. Appropriate actions to take for some of these incidents are provided in the following sections.

All radiation workers are responsible for reporting incident conditions to the RSU. These reports must be made at the earliest opportunity following discovery of the incident and no later than two hours afterward.

Examples of radiological emergencies are

1. Missing radioactive material
2. Spills of radioactive material that could potentially lead to airborne or surface contamination limits being exceeded
3. Release of radioactive material to the environment that could exceed limits
4. Receiving a dose in excess of administrative limits
5. Unexpected airborne materials that could cause an environmental or safety concern
6. Malfunction of a radiation-producing device with personnel receiving a dose in excess of 1 rem
7. Personnel contamination
8. Fire or flood involving radioactive material

17.3 Spill of radioactive material

Note: Under no circumstances must any untrained person attempt to examine or clean up any spilled radioactive material. Proper precautions taken immediately will protect the environment and worker health and safety. If you suspect that you are contaminated, stand fast and call for help. Minimize your movements to prevent the spread of contamination.
A radioactive material spill is defined as the inadvertent release of radioactive materials to an undesirable location with the potential of exceeding contamination limits. Radioactive spills are rarely a physical hazard in the research environment, but they have the potential to raise significant issues and incur considerable expense in the future to decontaminate university facilities. Spills of radioactive materials may jeopardize ongoing and future research activities. All spills of radioactive materials must be reported to the RSU (ext. 5-3781) or Security (ext. 13) within two hours of their occurrence. Research personnel involved in the spill must take the immediate actions noted below and must proceed with spill cleanup until RSU personnel arrive on the scene. At that time, RSU personnel may assume responsibility for continuing cleanup of the spill, may render assistance to laboratory personnel in completing spill cleanup, or may act in an advisory capacity. The immediate actions to be taken in the event of a radioactive materials spill are outlined below. The acronym used to remember these actions is “SWIMS”:

**Stop** the spill by capping any open container(s) and placing absorbent materials on top of spilled liquids. The purpose of this step is to take actions to prevent the spill from worsening. Taking these actions help contain the potential spread of radioactive contamination.

**Warn** others of the spill by announcing it to co-workers, posting a notice on the door to the laboratory (if appropriate), and contacting the Radiation Safety Unit or Security. These actions let others know of the spill so they can take appropriate actions such as rendering assistance, donning protective clothing, evacuating the area, or avoiding walking through the spill area, as appropriate for the specific instance.

**Isolate** the area by erecting boundaries, posting warning signs, or taking other actions as appropriate. This prevents the inadvertent contamination of personnel and limits the spread of contamination away from the spill area. No personnel may enter a spill area unless they don appropriate anti-contamination clothing such as shoe covers, a laboratory coat, and protective gloves. No personnel may leave a spill area until they have been surveyed and found to be free of contamination.

**Minimize** personnel exposure by carefully considering the extent of the spill, determining appropriate personal protective equipment, and conducting radiological surveys to delineate the spill area. This helps to maintain personal exposures as low as reasonably achievable.

**Stop** ventilation if possible and appropriate by turning off room or area ventilation, shutting ventilation dampers, or other appropriate measures. This reduces volatilization of liquid compounds and distribution of powdery solids.

Cleanup of the spill must commence immediately upon completion of the above immediate actions. Following decontamination, surveys must be performed using
appropriate equipment to verify cleanup to appropriate levels has been accomplished. Copies of these surveys will be maintained by the RSU and by the laboratory involved in the spill. These surveys must note the exact location and extent of spilled radioactive materials prior to commencing decontamination efforts, the contamination levels noted at the time of the spill, and post-cleanup contamination levels (both fixed and removable). In general, use the following rules of thumb when cleaning up a radioactive spill:

1. Clean from top to bottom on vertical surfaces or when contamination is at several different levels.
2. Clean from the outside to the inside of a spill.
3. Clean from areas of low contamination toward areas of high contamination.

17.4 Skin Contamination

Skin contamination refers to the presence of radioactive materials in direct contact with a person’s skin. Skin contamination is a concern because of the potential for very high localized radiation dose and because of the potential for uptake of radioactive materials attached to compounds that are absorbed through the skin and into the body. Skin contamination is almost entirely preventable through the proper use of protective clothing (gloves, lab coats, closed-toe shoes, wearing pants instead of shorts, and so forth). In the event that skin contamination does occur, the following procedure should be followed:

1. Notify the Radiation Safety Unit (ext. 5-3781) or Security (ext. 13) immediately.
2. Estimate the amount of radioactive material on the skin. This may be done by using an appropriate meter and recording the count rate, type of detector, and isotope.
3. Commence decontamination efforts, beginning with mild soap and cool or warm water. In general, do not take measures that cause pain or that may degrade the skin’s natural ability to act as a barrier. Decontamination efforts should continue until radiation safety personnel arrive, the decontamination is successful, or it is determined that continued efforts are inadvisable.

In the event of contamination with radioactive isotopes of iodine, a thyroid bioassay is required between 24 and 72 hours after the contamination occurs. In the event of contamination with a beta-emitting nuclide (H-3, C-14, S-35, P-32, for example) a urine bioassay is required between 24 and 48 hours after the contamination occurred. The purpose of these bioassay measurements is to determine if uptake of radioactive materials occurred. Personnel who are exposed to skin contamination must remain in or near their laboratory area until released by the RSU personnel.

17.5 Ingestion or Inhalation of Radioactive Materials

Potentially the most serious form of exposure to radioactive materials is via inhalation or ingestion since this brings radioactive materials into direct contact with living tissues and gives these materials a way to directly affect internal organs. Virtually all cases of ingestion or inhalation of radioactive materials can be avoided through the use of proper laboratory safety equipment including the use of fume hoods or face shields (when
appropriate) and the elimination of eating and drinking in the laboratory environment. Personnel who may have ingested or inhaled radioactive materials must remain in or near their laboratory area until released by RSU personnel. In the event there is a suspected uptake of radioactive materials through inhalation or ingestion, the following actions must be taken immediately:

1. Stop the source of uptake if possible (for example; leave the room, move into fresh air, spit contaminated liquids out of the mouth, blow your nose, etc.).
2. Notify Radiation Safety Unit (ext. 5-3781) or Security (ext. 13) immediately.
3. Estimate the amount of uptake to the best of your ability (save empty or partially empty stock vials, laboratory glassware, etc., that may help in this estimate).
4. Urine samples will be collected between 24 and 48 hours following any uptake of radioactive materials for bioassay. Personnel working with radioactive isotopes of iodine must have thyroid bioassay measurements performed between 24 and 72 hours following exposure.

17.6 Exposure to Abnormal and High Levels of X-ray, Beta, Gamma, or Neutron Radiation
Abnormal levels of x-ray, beta, gamma, or neutron radiation are those levels that exceed 50 µGy/hr (5 mrad/hr) or that result in off-scale readings on the highest setting of any survey instrument. Radiation levels of 50 µGy/hr (5 mrad/hr) pose no risk to personnel but are indicative of problems that must be investigated. In the event abnormal radiation levels are encountered, personnel must note the readings on their radiation survey instruments and immediately contact the Radiation Safety Unit (or Security after normal working hours). If radiation levels exceed 0.5 mGy/hr (50 mrad/hr), personnel must leave the area and assemble in a common area until released by RSU personnel. Depending on the perceived severity of the incident, Radiation Safety may collect or exchange radiation dosimetry at this time to ensure no personnel were exposed to excessive levels of radiation.

17.7 Loss of Radioactive Materials
Radioactive materials are considered lost if they cannot be located within 4 hours. Loss of radioactive materials is a serious concern that may have to be reported to the State of New York. If any worker feels they have lost radioactive materials, inform the RSU immediately. Be prepared to provide the following information:

1. The isotope(s) involved and the approximate activity of each
2. The radioactive materials HPA assigned stock vial inventory number
3. The last time that particular stock vial was used
4. The normal storage location
5. Actions taken to locate the missing stock vial
Upon arrival at the scene, the RSU will assist with attempting to locate the missing radioactive materials. If the materials cannot be located, all involved parties will be required to write a report detailing the circumstances surrounding the loss of radioactive materials and describing all actions taken. In addition, the RSU will determine the risk posed by the loss of radioactive materials (if any) and will report the loss to the NY Department of Health as required under the provisions of Part 16 of the New York Code of Rules and Regulations.

17.8 Fire or Flooding Involving Radioactivity
If a room containing radioactive materials is involved in fire or flooding, the following actions must be taken by personnel working in the area or noticing the problem:

1. Exit the area if you feel your life is in danger.
2. Immediately report the emergency to Security (ext. 13), including the fact that radioactive material is stored in the room in question.
3. During working hours, contact the Radiation Safety Unit at ext. 5-3781 to inform the RSU of the emergency.
4. DO NOT try to combat a fire yourself unless you are trained and your building is designated as “fight the fire,” such as the Laboratory for Laser Energetics.
5. If it is possible to isolate a source of flooding by operating an isolation valve or some other means, or to divert the water away from radioactive materials, try to do so.

17.9 Malfunction of High Energy Radiation Producing Machinery
Radiation-producing machinery includes high energy linear accelerators, irradiators, and similar devices designed to produce ionizing radiation. There are specific requirements for operating such machines, including a requirement that all safety alarms and interlocks be working correctly at all times. In the event of any malfunction in any radiation-producing device safety system, the following actions must be taken:

1. Exit the room containing the device immediately.
2. Contact Clinical Engineering.
3. Contact the RSO or RSU Medical Physicist (ext. 5-3781) during normal working hours (Security (ext. 13) after hours, on holidays, or weekends) if there is a higher than expected dose to patient or operator.
4. Attempt to determine if the device is emitting radiation.
5. If the device is emitting radiation, attempt to disable or secure it without entering the room in which the device is located.
SECTION 18: STORAGE OF RADIOACTIVE MATERIALS

Radioactive materials are stored as stock solutions, as experiments-in-progress, as radioactive waste, and for a variety of other reasons. Regardless of the form of the radioactive material and the reason for its storage, certain requirements must be met to fully comply with regulatory requirements and good radiation safety practices. These requirements are enumerated below.

1. Part 16 of the New York Code of Rules and Regulations (NYCRR part 16) requires that all areas in which radioactive materials are stored must be posted with the radiation symbol if the total activity in that area exceeds certain limits that vary according to the isotope. Limits for the most commonly used isotopes are listed in the table below. In the event multiple nuclides are stored in a single area, the sum of the ratios must not exceed 1.

2. All rooms, corridors, or other areas containing radionuclides in excess of these quantities must be posted with the radiation symbol.

3. All storage cabinets, lockers, refrigerators, freezers, or other storage locations must be marked with the radiation symbol and a list of the nuclide(s) and activity of each nuclide in that storage location.

4. All licensed radioactive materials must be secured against unauthorized removal at all times.

5. Radioactive material storage locations must be shielded so that radiation levels are less than 2 mrem per hour at a distance of 1 meter from any accessible surface.

6. Bulk liquids must be stored in a sealed container. These containers must be kept in a secondary containment to minimize the potential for contamination in the event the primary container is breached or damaged.

<table>
<thead>
<tr>
<th>Nuclide</th>
<th>Amount requiring posting</th>
</tr>
</thead>
<tbody>
<tr>
<td>H-3</td>
<td>3.7E+8 Bq (10 mCi)</td>
</tr>
<tr>
<td>C-14</td>
<td>3.7E+8 Bq (10 mCi)</td>
</tr>
<tr>
<td>P-32</td>
<td>3.7E+6 Bq (100 μCi)</td>
</tr>
<tr>
<td>S-35</td>
<td>3.7E+7 Bq (1 mCi)</td>
</tr>
<tr>
<td>Ca-45</td>
<td>3.7E+7 Bq (1 mCi)</td>
</tr>
<tr>
<td>I-125</td>
<td>3.7E+5 Bq (10 μCi)</td>
</tr>
</tbody>
</table>
SECTION 19: TRANSPORTATION OF RADIOACTIVE MATERIALS

19.1 Incoming Radioactive Material Shipments
1. All incoming radioactive shipments to the University of Rochester must be received and inspected by the RSU unless special arrangements approved by the RSO have been made. This includes radioactive materials that are considered exempt quantities or are generally licensed.

2. Numerous kinds of commercial equipment now contain radioactive materials in such small quantities that labeling or special packaging is not required by governmental shipping regulations. Personnel should be aware, however, that radiation and leakage from these items may cause technical interference with the sensitive radiation measurements made in many University programs.

3. All radioactive materials must be registered with the RSU regardless of the amounts involved or the method or type of fabrication of such material. This specifically includes all radioactive materials received from other-than-commercial vendors, such as other universities, private research organizations, or government laboratories. A strict inventory is required by the University’s Radioactive Materials License, which limits the total amount of radioactive material that may be possessed.

19.2 Outgoing Shipments of Radioactive Material
The RSU must make the final inspection, survey, and approval of all outgoing radioactive shipments from the University of Rochester.

1. Any person planning to ship radioactive materials should contact the RSU Office for shipping and packaging requirements prior to packaging any radioactive materials for shipment.

2. The RSU must ensure that the institution receiving the radioactive material is properly licensed by the NRC or an agreement state. The institution will be requested to furnish a copy of its radioactive material license to demonstrate proper licensing and authorization to receive a particular radioactive material.

19.3 Reports of Damaged Shipments
Any report of a damaged radioactive shipment from the University must be promptly referred to the RSU for investigation. Any decision to dispatch Radiation Safety personnel to the scene will depend upon such factors as the nature of the shipment, the extent of damage, the availability of competent personnel closer to the scene, and the requests of authorities having jurisdiction.
SECTION 20: RADIATION-GENERATING DEVICES

20.1 Hazards from Radiation-Generating Devices
Hazards from radiation-producing equipment are classified into primary beam hazards and scattered radiation. The fact that adequate shielding against either the primary or the secondary radiation can be designed to eliminate such radiation hazards requires, in principle, well-defined rules for the elimination of such hazards.

20.2 Rules for Safe Operation

20.2.1 General Requirements
1. Any facility having radiation-generating devices must be surveyed for possible exposure hazards to the operators.

2. Radiation-generating devices include, but are not limited to, x-ray machines, fluoroscopy units, CT scanners, linear accelerators, x-ray diffraction units, electron microscopes, and other devices that produce ionizing radiation as a result of their normal operation.

3. Consistent with the findings of such surveys, specific operational limitations must be observed, and changes in protection design must be carried out before the installation is approved for continued operation.

4. Dosimeters must be worn by operators if exposures greater than 10% of those allowed in Section 7 are possible, or if the equipment is capable of producing greater than 50 µSv (5 mrem) in 1 hour in an accessible area at a distance of 30 centimeters from the tube.

5. Radiation-generating devices must be surveyed during the initial operation of such equipment and whenever any change is made in the installation that might change the radiation level to which a person could be exposed. In evaluating the results of the survey, the actual operating conditions, including workload, use factor, occupancy and attenuation of the useful beam by patients or objects, must be the criteria for recommendations of changes. Inspections based on the potential change to output should be performed prior to any patient use.

6. X-ray machines including but not limited to mobile and fixed X-ray, Fluoroscopy, Dental and Computed Tomography will also be surveyed at a frequency and at the direction of the New York State Department of Health as specified in 10 NYCRR 16.10.

7. It is the responsibility of the machine custodian that inspectors have access and the necessary accompanying accessories (i.e. fluoroscopy table or equivalent, etc.) for the device during the period the devise is due for inspections.

8. A written record of all surveys will be presented to the individual responsible for each unit within one week after the survey unless the survey indicates abnormal values in which case the responsible individual should be informed immediately. All serious violations, i.e., those that endanger patients or personnel, must be corrected immediately or the unit must be shut down until such corrections can be made. Other, less serious violations must be corrected within a 30-day period.
Written notice of all necessary corrections will be presented to the responsible individual and a re-inspection will be made subsequently. A re-inspection will be made, and written notice of all necessary corrections will be presented to the responsible individual.

20.2.2 Fluoroscope Operation
1. Fluoroscopic equipment must be operated only by persons authorized by the individual in charge of the installation.
2. Approved radiation protective aprons must be worn during fluoroscopy.
3. The exposure to the patient must be kept at a minimum consistent with clinical requirements. Methods of reducing patient exposure include, but are not limited to increasing voltage, increasing beam filtration, and reducing exposure time.
4. Dosimeters must be worn by physicians at the level of the neck and outside of the apron, and at the waist underneath the apron. In lieu of the double dosimeter arrangement, a single dosimeter may also be at the level of the neck and outside of the apron. Appropriate corrections to the dosimetry results must be completed by the RSO and provided to the physicians.
5. Physicians, who may also receive extremity exposures, such that the dose could exceed 5,000 mrem in a year or 1,875 mrem in a calendar quarter, must wear extremity dosimeters.
6. All radiation burns to patients must be reported to the RSU within one working day of occurrence. Refer to Appendices B and C

20.2.3 Medical X-rays
1. Normally, no person should hold patients during x-ray exposure. If circumstances require such action, however, the person holding the patient must wear protective aprons and gloves and avoidance of exposure to the direct beam is mandatory. Members of the public such as caregiver will be issued dosimetry and the exposure will be recorded in the modality hold log.
2. The exposure to the patient should be carefully restricted to the part under investigation.
3. Dosimeters must be worn by technologists.
4. Technologists must be provided with references on average patient radiation doses for the examinations that they are expected to perform.
5. Technique charts must be available for technologist use and reference.
6. All radiation burns to patients must be reported to the RSU within one working day of occurrence.

20.2.4 Radiation Therapy
1. No person other than the patient must be in the treatment room during the exposure.
2. The facility must be operated in compliance with limitations indicated by RSU inspections.
3. The patient and the control panel must be kept under observation during patient treatment.
4. Dosimeters must be worn by technologists.
SECTION 21: USER TRAINING PROGRAMS

It may not be assumed that radiation safety instruction has been adequately covered by prior professional or occupational training or by board certification. In addition to radiation workers, ancillary personnel (e.g., nursing, clerical, housekeeping, security) whose duties may require them to work in the vicinity of radioactive material need to be informed, by their department, about radiation hazards and appropriate precautions. Personnel will be instructed

1. before assuming duties with, or in the vicinity of, radioactive materials;
2. during annual refresher training; and
3. whenever there is a significant change in duties, regulations, or the terms of the University’s Radioactive Material License.

21.1 Training and Experience for Medical Uses of Radioactive Material

Any human use of radioactive material (i.e., the internal or external administration of radioactive material or the radiation exposure to human beings) must be carried out under the supervision of a professional practitioner. Such application of or order to apply radiation must be in the course of the practitioner’s professional practice and must comply with the provisions of the University’s radioactive material license or other authorization of the practitioner under the Education Law of New York State.

21.1.1 Diagnostic Procedures-Group I: Uptake, Dilution, and Excretion Studies

Physicians, technicians, and other persons involved in the medical use of radiation and/or radioactive materials for the diagnosis and/or treatment of diseases in humans must meet the training and experience requirements specified in Appendix A of New York Radiation Guide 10.1, Revision 2. Physicians wishing to prescribe the use of radiation or radioactivity for the diagnosis or treatment of diseases in humans must be approved by the RSC. Physicians who have not been approved for such use by the RSC may work only under the supervision of an approved physician.

21.2 Training for Non-Medical Uses of Radioactive Material

Instruction will be provided initially and as annual refresher training. Initial training consists of the MyPath training course and passing an examination with a score of 80% or greater. The class requirement may be waived by the RSO for personnel who have previously worked with radioactive materials and are unable to attend the scheduled class. All personnel, however, must pass the examination in order to become authorized radiation workers. Areas to be covered during training will include, but are not limited to

1. Applicable regulations and license conditions
2. Areas where radioactive material is used or stored
3. Potential hazards associated with radioactive material in each area where the employees will work
4. Appropriate radiation safety procedures
5. University radiation safety procedures and policies
6. Each individual’s obligation to report unsafe conditions to the RSO
7. Appropriate response to emergencies or unsafe conditions
8. Worker’s right to be informed of occupational radiation exposure and bioassay results
9. Locations where notices, pertinent regulations, and copies of pertinent licenses and license conditions are maintained (including applications and applicable correspondence), as required by Part 16.13

All radiation workers are required to receive annual refresher training. This training may include any of the following:
1. Taking MyPath refresher training class that includes the above information and a final quiz or examination.
2. Training administered by the Permit Holder, after which an examination is given. A short training syllabus, attendance sheet, and examination grades from such training must be forwarded to Radiation Safety.
3. Attendance at regularly scheduled radiation safety in-service training and signature of attendance.
4. Attendance at a training session administered by any health physicist to laboratory staff. Such sessions will normally be scheduled at five year intervals for all laboratories.

21.3 Training and Experience for Users of Gamma-Ray Irradiators
1. Personnel must attend initial qualification training for gamma irradiators and must have annual refresher training.
2. The authorized user for the gamma irradiation must provide the initial and annual training that is approved by the RSO. The RSU will maintain records of initial qualification and annual recertification.
3. The initial and annual refresher training must consist of
   * principles and fundamentals of radiation safety and good safety practices related to the use of radioactive materials;
   * use of radiation-detection instruments;
   * the design and operation of the irradiator;
   * applicable regulations and license conditions;
   * potential hazards associated with the irradiator in each area where the employees will work;
   * appropriate radiation safety procedures;
   * university radiation safety procedures and policies;
   * each individual’s obligation to report unsafe conditions to the RSO;
* appropriate response to emergencies or unsafe conditions;
* worker’s right to be informed of occupational radiation exposure and bioassay results;
* locations where notices, pertinent regulations, and copies of pertinent licenses and license conditions are maintained (including applications and applicable correspondence), as required by Part 16.13; and
* a question-and-answer period.
SECTION 22: MEDICAL USE OF RADIOACTIVE MATERIALS

Permission to use radionuclides in patients for experimental, diagnostic, or therapeutic purposes must be obtained from the Human Use of Radioisotopes Committee in the Medical Center in addition to the application submitted to the RSU.

All physicians using radioactive materials or radiation for diagnostic or therapeutic procedures must be approved by the RSC or a subcommittee of the RSC prior to prescribing these procedures. The procedure for such approval is maintained by the RSU. The RSU also maintains a file containing, for each medical department, the names of physicians who have been approved for this use, the treatment modalities for which they have been approved, and copies of the documents upon which this approval was based.

22.1 Outpatients

1. No records are required for outpatients by the RSU. No notification of outpatient treatment to the RSU is necessary.

2. When the total effective dose equivalent to any individual from the release of a patient is likely to exceed 100 mrem, the patient or his/her competent representative must be provided written information on risks of radiation and methods for reducing the exposure of individuals. Records of such patient release must be maintained for 5 years.

3. At no time may a patient be provided outpatient treatment using radioactive materials when a member of the general public may be reasonably expected to receive a dose in excess of 500 mrem from the treated patient.

22.2 All Inpatient Treatments Utilizing Radioactive Materials

1. RSU personnel will attend the administration of therapeutic doses of radioactive materials that are implanted, injected, or swallowed.

2. The patient or a competent representative will be provided information regarding radiation safety precautions to be followed during treatment and after release from the hospital. This information will be provided by either the RSU or the admitting department.

3. RSU personnel will measure radiation levels near the patient to determine stay times for visitors and nursing staff, ensure the room is properly posted, measure radiation levels in adjacent rooms and post as necessary, and provide the patient with radiation safety instructions that are pertinent and applicable to their treatment.

4. The patient’s room will be as far away from the nursing station and heavy traffic hallways as is consistent with good medical care. It will be a private room with private sanitary facilities and no carpet.

5. A visitor’s “safe line” should be marked on the floor with tape as far from the patient as possible.

6. A member of the RSU staff will perform a radiation survey following each administration of therapeutic doses of radiopharmaceuticals or implanted radioactive sources. Survey points include, but are not limited to, the patient’s
bedside, the foot of the bed, the visitor’s chair, the door into the room, and the wall
of adjacent rooms.

7. Stay times for nursing staff at bedside will be calculated based on these figures.
Stay times will be determined such that any nurse caring for radioactive patients
five days weekly for an entire year will not exceed an annual radiation dose of 20
mSv or 2,000 mrem.

8. Stay times for visitors must be calculated such that no visitor will receive a radiation
dose in excess of 0.5 mSv (50 mrem) during the expected duration of the patient’s
stay.

9. Radiation Safety must post the patient’s room door with a “Radioactive Materials”
sign, a Radiation Safety Notice for nurses that lists important phone numbers, and
stay-times in the patient’s room.

22.3 Inpatient Radiopharmaceutical Therapy

1. The RSU is required to keep records of all patients receiving radiopharmaceutical
therapy. If the pertinent information (time of application, activity of the radioactive
material, unit number, etc.) is not available at that time, the RSU must be notified
immediately upon receipt of this information.

2. The rooms must be set up to minimize the potential for contamination during the
patient’s stay by covering the floor, doorknobs, chairs, and other objects likely to be
touched with plastic or plastic-backed absorbent material. Rooms that are for the
dedicated use of nuclear medicine patients need not be prepared in this manner
because of their limited use.

3. Patients must not bring any personal effects into the room with them unless the
physician deems them necessary for the patient’s psychological well-being during
their stay. Personal effects will be considered contaminated and must be disposed of
as radioactive waste upon the patient’s discharge. Street clothing may be brought
but must remain in the closet until the patient dresses for discharge.

4. Disposable table service should be used for the duration of the patient’s stay. SMH
Housekeeping personnel should be informed to stay out of the room when the room
is posted with the radiation symbol.

5. For patients containing therapeutic quantities of radioactive material the following
procedures apply:

* The patient will remain hospitalized.

* The patient will wear a wrist band until either the residual radioactivity in the
patient is less than or equal to 1.1 E+8 Bq (30 mCi), the activity of the
radionuclide is such that the total integrated dose at one meter from the patient
will not exceed 50 mSv (0.5 rem) during complete decay, or the total effective
dose equivalent for an individual (other than the patient) is less than 5 mSv (500
mrem), whichever is more limiting. The wrist band must bear the radiation
symbol, the quantity and type of radioactive material administered, and the date
on which such quantity was measured.
* Separate plastic-lined boxes for linen, disposable waste, and non-disposable contaminated items will be provided.

* If urine is collected, a wide-mouth funnel and containers with unbreakable caps will be provided and placed into another container or tray that has been lined with plastic or an absorbent material. The containers should have at least 3 millimeters of lead shielding.

* Nurses working with these patients must wear radiation dosimetry.

* Nurses must be briefed annually on radiation safety procedures by the RSU.

* The patient must be briefed on radiation safety procedures for the dosage administration, visitor control, urine collection, radioactive waste, and other applicable items by the RSU or Nuclear Medicine.

6. All personnel entering the patient’s room must don shoe covers and protective gloves prior to entering the room. Upon exiting the patient’s room, the shoe covers must be removed followed by the gloves. Gloves and shoe covers must be placed in a small waste container maintained at the patient’s door for this purpose.

7. Only persons needed for medical, safety, or training purposes must be present during the administration of radiopharmaceutical therapy. Personnel must wear gloves and work within fume hoods when opening containers of volatile radiopharmaceuticals such as Iodine 131 (I-131).

8. Personnel who were present for the administration of I-31 must monitor their thyroids one day after the administration to determine if an iodine intake occurred. Nursing staff are not required to receive thyroid monitoring provided they observe proper radiation safety precautions. Thyroid-monitoring procedures and equipment are available in the RSU.

9. As the therapy proceeds, the RSU will pick up waste for transfer to the decay in storage facility area.

10. Sputum or emesis from patients receiving therapeutic doses of non-sealed radionuclides should be saved in a suitable container that will be surveyed by the RSU before disposal.

11. Before using the patient’s room for general occupancy, it must be decontaminated and released to the Admitting Office.

22.4 Radiation Safety for Therapeutic Use of Sealed Sources in Implants

1. The patient will be briefed on radiation safety procedures by Radiation Oncology as appropriate.

2. If the implant is performed in other than the patient’s room, the area used for the procedure will be surveyed by the RSU immediately afterward. In the case of seeds, any area where the seeds were handled (e.g., sterilization areas, source storage room, etc.) will be surveyed immediately after use.

3. Radiation levels in unrestricted areas will be maintained less than the limits specified in 10 NYCRR 16.7.
4. Nurses caring for brachytherapy patients will be assigned radiation dosimetry. Declared pregnant nurses must not be assigned to the care of these patients. Bed baths should be omitted while the sources are in place. Perineal care should not be given during gynecologic treatment; however, the perineal pad may be changed when necessary unless orders to the contrary have been written. Surgical dressings and bandages used to cover the area of needle insertion may be changed only by the attending physician or Radiation Oncologist and may not be discarded until directed by Radiation Oncology.

5. Special orders must be written for oral hygiene of patients with oral implants.

6. No special precautions are needed for sputum, urine, vomitus, stools, dishes, instruments, or utensils unless specially ordered by Radiation Oncology. If nursing feels that a source could have been inadvertently displaced into any these items, the RSU should be contacted immediately for a survey of the item(s).

7. Patients must stay in bed unless orders to the contrary are written. In any event, patients will remain in their assigned rooms during the treatment period.

8. Visitors are limited to those 18 years of age or over unless other instructions are noted on the precaution sheet on the patient’s chart.

9. Visitors should sit at least 3 feet from the patient and should remain no longer than the time specified on the form posted on the patient’s door or on his or her chart. The visitor’s safe line should be observed.

10. At the conclusion of treatment, a survey will be performed by the RSU to ensure that all sources other than permanent implants have been removed from the patient and that no sources remain in the patient’s room or in any other area occupied by the patient. At the same time, all radiological postings will be removed from the patient’s door.

11. If any applicators or sources are found fully or partially dislodged from a patient, or the position of the applicator has moved, the nurse or attendant must leave the room immediately and notify the Division of Radiation Oncology. In no case must a nurse or attendant, or a Resident other than from Radiation Oncology, attempt to remove, replace, or otherwise transport any source or applicator. The RSU will render assistance when requested.

12. All linen and dressings must be saved in the patient’s room. These will be checked by the RSU prior to disposal in order to avoid misplacement of any radioactive source.

13. Following removal of temporarily implanted sources, the RSU staff must perform a radiation survey of the patient to ensure that all sources were properly removed from the patient and the room. This responsibility may be delegated to Radiation Oncology with their concurrence if the source removal will take place after normal working hours and if no RSU personnel can provide this coverage. The results of the post-source withdrawal survey must be recorded on the patient information sheet and retained by the RSU. Radiation Oncology will inventory the sources prior to discharging the patient.
22.5 Radioactive Cadavers

1. If any patient containing radioactive material expires, it must be the responsibility of the physician who pronounces such patient as dead to notify the physician in charge of the case.

2. No autopsy of any cadaver containing in excess of 1.9E+8 Bq (5 mCi) of any radioactive element must be performed without prior consultation with the RSU. A radioactivity report must be filled out for cadavers containing more than 1.9E+8 Bq (5 mCi) of radioactivity as prescribed in 10 NYCRR 16.9(d).

22.6 Management of Patients in the Operating Room

1. When radioactive seeds are implanted, the Operating Room (OR) must be surveyed by the RSU personnel after the patient has left the OR.

2. During such procedures, all waste containers, rinse waters, fluids, linens, surgical equipment, the OR floor and table, and other areas and items must be checked for the presence of radioactive seeds during the procedure and after the patient is removed from the OR. The purpose of this survey is to ensure that no radioactive sources are inadvertently disposed of in an improper manner.

3. It must be the responsibility of the Division administering the implant to supply personnel-monitoring devices to OR personnel when deemed necessary by the RSU. This decision will be made on an individual basis, but as a guideline, most implants of less than 1.1 GBq (30-mCi) total activity will not necessitate the use of personnel monitoring by OR personnel if the implant procedure is short and the frequency of such procedure is low. In no case must pregnant personnel assist in an implant procedure.

4. If it is necessary to hold the implanted patient in the Recovery Room, the following precautions must be observed:
   * At least 10 feet of separation distance will be maintained to the next patient in the Recovery Room.
   * Other patients who are pregnant should not be in the vicinity of the implanted patient.
   * Place a “CAUTION RADIATION AREA” sign on each end of the transport bed. (This must be the responsibility of the Division administering the implant.)
   * Personnel monitoring of Recovery Room staff will not normally be required.

4. If emergency surgery is required of a radioactive patient, the RSU should be consulted.

22.7 Transport of Patients

1. A person from the Division administering the radiation should accompany any patient with over 1.1 GBq (30-mCi) of any radioactive material. If the patient is left unattended at any time, a “CAUTION RADIATION AREA” sign must be placed on each end of the transport bed.

2. Escort personnel, when used, must be instructed to handle the patient expeditiously and remain away from the patient if waiting periods arise.
3. Elevators used for transport must be cleared of all personnel not essential to the care or transport of that patient.

22.8 Surgical Removal or Biopsies of Tissues Containing Radioactivity

Some tissues, such as sentinel nodes, that contain radioactive materials may be removed. Studies performed by other institutions, including the Mayo Clinic, the Veterans Administration, and others, have shown the radiation dose and risk to OR and Pathology staff is minimal during such procedures. The amount of radioactive materials used during these procedures are similarly small. Accordingly, such tissue samples may be transported from the OR to the laboratory without radiological precautions. The following precautions are required, however, during such procedures:

1. RSU staff must be notified of all such samples. If possible, this notification should take place at least one day in advance of the procedure.

2. Analysis of such tissues must be conducted over nonporous surfaces (such as stainless steel) that are covered with plastic-backed absorbent paper.

3. Upon the completion of these analyses, the work area must be surveyed for radioactive contamination by laboratory personnel.

4. In the event the tissue sample is found to contain radioactive sources (e.g., a sample of prostate tissue containing implanted seeds), the RSU must be contacted immediately. Such samples must be transported by the RSU or other qualified radiation workers. Following analysis, the RSU will take possession of the radioactive seeds. Adhering tissue must be removed from such seeds by the laboratory to the maximum extent possible.
SECTION 23: OPERATION OF LLE’S TRITIUM FILLING STATION AND OMEGA LASER SYSTEM

The information below is in addition to detailed procedures contained in the LLE Radiological Controls Manual.

23.1 Sources and Production of Radiation

The Tritium Filling Station (TFS) is located in Room 157 at the Laboratory for Laser Energetics (LLE). This facility is used to fill plastic micro-balloons used for inertial confinement fusion experiments on the OMEGA Laser System. The operating procedures established for this facility were used to support NYS’ issuance of an amendment to the University’s radioactive material license to handle 10,000 curies of tritium.

The OMEGA 60-beam laser system is used to conduct research in support of the Department of Energy’s national inertial confinement fusion program. As part of this program, small micro-balloons containing fusion fuel (either deuterium–deuterium or deuterium–tritium) are imploded by the OMEGA’s 60-beam laser system with up to 30 kilojoules of energy. Initial targets will produce up to $1 \times 10^{14}$ neutrons/shot, and ultimately the maximum credible yield may reach $3 \times 10^{15}$ neutrons/shot. The target chamber is located in a Target Bay that is surrounded by a concrete shield wall that is designed to limit external radiation to less than 250 μSv (25 mrem) per year. However, inside the Target Bay radiation levels could reach a maximum of ~40 μSv (4 rem) per shot at a shot repetition rate of one per hour. Additionally, because of proximity and construction, the Laser Bay and Neutron Diagnostics building radiation levels could reach a maximum of ~170 and 40 mrem per shot, respectively.

As the Target Chamber and surrounding steel structures in the Target Bay become irradiated with neutrons, the walls will become activated and become sources of gamma radiation. To minimize activation, the Target Chamber was constructed of aluminum. The primary nuclides that contribute to this activation dose are Na-24 ($T_{\frac{1}{2}} = 15$ days) and Mn-54 ($T_{\frac{1}{2}} = 312$ days), which are formed from trace elements in the aluminum. Calculations show that after 12 maximum credible neutron-yield shots per year over a ten-year period, the radiation level from activation would be reduced to less than 1 mrem per hour at the surface of the chamber in approximately two days after the last shot. However, maximum credible yield shots are unlikely for several years, by which time all target diagnostics will be remoted, making entrance into the Target Bay after each shot unnecessary.

23.2 Operating Procedures

1. The Tritium Filling Station design ensures that no single failure will result in the uncontrolled release of tritium. To ensure that the TFS is operated safely the LLE Radiological Safety Officer is responsible for ensuring compliance with approved procedures. These procedures require that

   a. The operators receive requisite training on TFS operations and on tritium radiological control procedures.
b. The TFS is maintained in accordance with the approved preventative maintenance procedures.

c. Wipe contamination surveys are conducted weekly when the facility is in operation.

d. Urine samples are collected and analyzed weekly from operators when the facility is in operation.

e. The radiation exhaust integral monitor is in operation whenever tritium is stored in the facility.

f. LLE personnel are trained in the Emergency Procedure for Acute Release of Tritium.

2. The OMEGA Laser System incorporates interlocks that provide personnel protection from laser and nuclear radiation. The system is operated under the direction of a shift Shot Director; he/she is responsible for ensuring operations are conducted in accordance with approved operational and safety procedures. Additionally, the LLE Radiological Safety Officer ensures that the operations personnel comply with radiological control procedures. System operating procedures require that

a. The Target and Laser Bays and the Neutron Diagnostics building must be verified by personal inspection to be free of all personnel prior to commencing certain shot operations. Once verified to be empty of personnel the interlock system must be activated to physically preclude entry.

b. “Caution High Radiation Area” signs must be activated at entrances to the Target and Laser Bays and Neutron Diagnostics building prior to target shot operations that are expected to produce greater than $1 \times 10^{10}$ and $1 \times 10^{12}$ neutrons, respectively.

c. “Caution Radiation Area” signs must be activated at entrances to the Target Bay when radiation levels due to neutron activation are expected to be greater than 5 mrem per hour at 30 cm from the Target Chamber.

d. A radiation survey must be performed in the Target Bay prior to allowing general access whenever one of the following conditions exist: a target shot yields in excess of $5 \times 10^{13}$ neutrons; the integrated neutron level exceeds $3 \times 10^{16}$ neutrons; or a previous radiation survey conducted at least two days after shot operations indicated greater than 5 mrem per hour at 30 cm from the Target Chamber.

e. All personnel who break the boundary of the Target Chamber, diagnostics, vacuum systems, or other components that have been exposed to tritium and those personnel engaged in decontaminating tritiated components must have received appropriate training.

f. Wipe contamination surveys are conducted whenever opening a system that has been exposed to tritium.
g. Urine samples are collected and analyzed weekly from operators who have been potentially exposed to tritium.

h. Film badges are worn by anyone who enters the Target Bay when the area is designated a Radiation Area.

i. The radiation exhaust monitor is in operation whenever the Target Chamber or diagnostic vacuum systems are in operation.

j. Exhaust from the Target Chamber and cryogenic pumps are regenerated through the tritium scrubber.
SECTION 24: EXPERIMENTAL AND MEDICAL USE OF IODINE AND VOLATILE COMPOUNDS

Iodine is a volatile element that is part of many compounds. Other radionuclides such as tritium are also used as part of volatile compounds at times. In addition, many compounds are easily absorbed through the skin. Any uptake of radioactive materials, especially iodine, carries with it increased chance for elevated radiation dose to internal organs. The potential for uptake must be kept as low as reasonably achievable, and, if a person is exposed to possible uptake, it must be determined as quickly as possible so an accurate dose assessment may be performed. Examples of compounds in this category include

- Sodium iodide
- $^{35}$S Methionine
- $^{3}$H- NaBH$_4$, succinic anhydride, and acetic anhydride
- Compounds that are heated sufficiently that vapors may be released (e.g., heating tritiated water)

24.1 Precautions for Working with All Volatile Compounds (Including Iodine Isotopes)

1. All work must be performed in a fume hood. Respiratory protection is not normally required if the fume hood is working properly.
2. Fume hoods must be checked for proper air flow rates at least annually.
3. The fume hood opening must not be obstructed in such a way that airflow is impeded or eddies can form that could result in releasing radioactive materials from the fume hood.
4. Notify the RSU immediately in the event of a spill or failure of a fume hood while working with these compounds. The RSU will determine if a bioassay is necessary.
5. If stock solutions in excess of 1.9 E+8 Bq (5 mCi) are to be used, contact the RSU prior to such use. The RSU will perform a dose assessment to determine if carbon filtration or other precautions are required.
6. The limits shown in Table 1 may be adjusted by the RSO if a researcher can demonstrate that the physical or chemical forms of the compounds they are working with are not volatile.
7. Urine or thyroid bioassay will be required for all personnel who handle stock vials containing more than one Allowable Level for Intake (ALI) of any volatile radionuclide or radionuclide attached to a volatile chemical. Table 1 gives examples of some of these values.
Table 1
Isotope-use limits requiring bioassay. If a worker’s isotope usage in a single application exceeds these limits, bioassay will be required. Continuing use of more than 1 ALI in any month also requires a thyroid bioassay. Fume hood filtration requirements are based on the single-use limit.

<table>
<thead>
<tr>
<th>Nuclide</th>
<th>1 ALI</th>
</tr>
</thead>
<tbody>
<tr>
<td>H-3</td>
<td>29 GBq (80 mCi)</td>
</tr>
<tr>
<td>C-14</td>
<td>7.4 E+7 (2 mCi)</td>
</tr>
<tr>
<td>S-35</td>
<td>7.4 E+8 (20 mCi)</td>
</tr>
<tr>
<td>I-125</td>
<td>3.7E+7 (1 mCi)</td>
</tr>
<tr>
<td>I-131</td>
<td>3.7E+7 (1 mCi)</td>
</tr>
</tbody>
</table>

24.2 Additional Precautions for Working with Radioactive Iodine Compounds
1. All work with iodine compounds must take place in an approved and properly labeled fume hood.
2. Any work with stock solutions in excess of 1 mCi of iodine must take place in a fume hood that is designed for work with radioactive materials. Such hoods must contain carbon-filtered exhaust systems and stainless steel ductwork upstream of the filter.
3. All personnel working with stock solutions containing more than 1 mCi of any iodine isotope must receive a thyroid bioassay at least 24 hours afterward and no later than 72 hours after such work.
4. All personnel having skin contact with liquids containing iodine isotopes must receive a thyroid in-vivo bioassay at least 24 hours afterward and no later than 72 hours after the contact.
5. All personnel involved in decontamination of a spill containing any radioactive isotope of iodine must receive a thyroid bioassay at least 24 hours afterward and no later than 72 hours after the spill.
6. Personnel working with iodine or volatile radioactive compounds on a regular basis may, with the concurrence of the RSO, receive monthly bioassay measurements.
7. The RSU will review isotope-use records to verify that bioassays are performed as required.
SECTION 25: MAINTENANCE ON CONTAMINATED OR POTENTIALLY CONTAMINATED EQUIPMENT

Many laboratories contain equipment that may be contaminated with radioactivity. Such equipment includes, but is not limited to,

1. Refrigerators and freezers in which radioactive materials are stored
2. Fume hoods in which radioactive materials are used or stored
3. Centrifuges, incubation ovens, and other pieces of large analytical equipment
4. Ventilation ducts, fans, filters, and other equipment downstream of a radioactive fume hood

Such equipment must be labeled with the radiation symbol if the potential for contamination levels in excess of 500 dpm/100 cm² exists.

When contaminated or potentially contaminated equipment requires repair or calibration, it must be surveyed and cleared by a qualified radiation worker prior to commencing repairs or (in the case of portable equipment) prior to removal from a posted laboratory. The sequence of operations required in such cases should be as follows:

1. Laboratory requests repair of equipment and notifies Maintenance that equipment is used for radiological work.
2. Laboratory contacts Radiation Safety to request survey of broken equipment. Any qualified radiation worker may perform the equipment survey and decontamination in accordance with this section; however, all such surveys will be documented and verified by Radiation Safety within one working day.
3. Radiation Safety (or qualified radiation worker) performs survey and informs Maintenance of the results.
4. If the equipment is contaminated, Radiation Safety will either decontaminate the equipment, request the laboratory staff decontaminate the equipment, or provide radiological coverage during maintenance work on it, according to the desires of the permit holder. If laboratory staff decontaminates the equipment, decontamination must be verified by Radiation Safety prior to repair work commencing.
5. The equipment will be posted with tag or sticker indicating it has been cleared for maintenance work and the date and time of the survey.
6. Maintenance staff will perform repair work and inform Radiation Safety upon completion. Maintenance staff will remove radiological clearance tag or sticker for return to Radiation Safety.
Appendix A
Current Radioisotopes used at University of Rochester

<table>
<thead>
<tr>
<th>Radioisotope found at the UR in current use.</th>
<th>Half life</th>
<th>Principal decay that impacts the UR</th>
<th>Energy of the decay product</th>
<th>Other radiological concerns</th>
<th>Method of detection</th>
<th>Radiological Risks</th>
<th>Shielding material</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Am-241</strong> (Americium)</td>
<td>546 years</td>
<td>Alpha</td>
<td>5 MeV</td>
<td>0.06 MeV photons</td>
<td>Ion chamber</td>
<td>Internal</td>
<td>lead</td>
</tr>
<tr>
<td><strong>C-14</strong> (Carbon)</td>
<td>5730 years</td>
<td>Beta</td>
<td>0.1564 MeV</td>
<td></td>
<td>Ion Chamber</td>
<td>None</td>
<td>plastic</td>
</tr>
<tr>
<td><strong>Cl-36</strong> (Chlorine)</td>
<td>301,000 years</td>
<td>Beta</td>
<td>0.710 MeV, 0.233 MeV average</td>
<td>Pancake GM probe</td>
<td>Lungs when inhaled and lower large intestine for ingestion.</td>
<td>Plastic</td>
<td></td>
</tr>
<tr>
<td><strong>Co-57</strong> (Cobalt)</td>
<td>270.9 days</td>
<td>Gamma</td>
<td>0.122 MeV</td>
<td></td>
<td>Ion Chamber</td>
<td>Whole body</td>
<td>lead</td>
</tr>
<tr>
<td><strong>Co-60</strong> (Cobalt)</td>
<td>5.27 years</td>
<td>Gamma ray</td>
<td>1.73 and 1.33 MeV</td>
<td></td>
<td>Ion chamber</td>
<td>Whole body</td>
<td>lead</td>
</tr>
<tr>
<td><strong>Cs-131</strong> (Cesium)</td>
<td>10 days</td>
<td>Gamma ray</td>
<td>0.029 MeV</td>
<td>Brachytherapy</td>
<td>Ion Chamber</td>
<td>Whole body</td>
<td>lead</td>
</tr>
<tr>
<td><strong>Cs-137</strong> (Cesium)</td>
<td>30 years</td>
<td>Gamma ray</td>
<td>0.662 MeV</td>
<td></td>
<td>Ion Chamber</td>
<td>External whole body</td>
<td>lead</td>
</tr>
<tr>
<td><strong>F-18</strong> (Fluorine)</td>
<td>109 minutes</td>
<td>Annihilation Gamma ray</td>
<td>0.511 MeV</td>
<td>Positron emission</td>
<td>Ion Chamber</td>
<td>External whole body</td>
<td>lead</td>
</tr>
<tr>
<td><strong>H-3</strong> (Tritium)</td>
<td>12 years</td>
<td>Beta</td>
<td>0.1 MeV</td>
<td>Whole body dose internal</td>
<td>Liquid scintillation</td>
<td>Internal whole body</td>
<td>plastic</td>
</tr>
<tr>
<td><strong>I-123</strong> (Iodine)</td>
<td>13.13 hours</td>
<td>Gamma ray</td>
<td>0.159 MeV</td>
<td>Thyroid internal dose</td>
<td>Ion Chamber</td>
<td>Thyroid</td>
<td>Lead</td>
</tr>
<tr>
<td><strong>I-125</strong> (Iodine)</td>
<td>60 days</td>
<td>Low energy gamma ray</td>
<td>0.035 MeV</td>
<td></td>
<td>Ion chamber</td>
<td>Thyroid</td>
<td>lead</td>
</tr>
<tr>
<td><strong>I-131</strong> (Iodine)</td>
<td>8 days</td>
<td>Beta and gamma ray</td>
<td>0.365 MeV, Gamma ray</td>
<td>Internal dose to the thyroid</td>
<td>Ion chamber</td>
<td>External whole body, or thyroid</td>
<td>lead</td>
</tr>
<tr>
<td><strong>In-111</strong> (Indium)</td>
<td>2.80 Days</td>
<td>Gamma ray</td>
<td>0.2454 MeV</td>
<td></td>
<td>Ion Chamber</td>
<td>Whole Body, Platelets</td>
<td>Lead</td>
</tr>
<tr>
<td><strong>P-32</strong> (Phosphorous)</td>
<td>14.3 days</td>
<td>Beta</td>
<td>1.7 MeV, beta max, 0.6 MeV beta aver</td>
<td>Bremsstrahlung X-ray radiation when in high density materials</td>
<td>GM tube or Ion Chamber</td>
<td>Internal (inhalation or ingestion) and external from X-rays</td>
<td>High density plastic, followed by lead outside</td>
</tr>
<tr>
<td><strong>P-33</strong> (Phosphorous)</td>
<td>25 days</td>
<td>Beta</td>
<td>0.248 MeV</td>
<td></td>
<td>Ion chamber</td>
<td>Bone Marrow, Lung, GI track</td>
<td>High density plastic</td>
</tr>
<tr>
<td><strong>Pd-103</strong> (Palladium)</td>
<td>16.99 days</td>
<td>Gamma ray</td>
<td>0.357 MeV</td>
<td></td>
<td>Ion chamber</td>
<td>External dose, whole body</td>
<td>Lead</td>
</tr>
<tr>
<td><strong>Ra-223</strong> (Radium)</td>
<td>11 days</td>
<td>Alpha</td>
<td>4 to 6 MeV</td>
<td></td>
<td>Plastic Scintillation</td>
<td>Internal whole body, radium is a bone seeker</td>
<td>No external risk</td>
</tr>
<tr>
<td>Isotope</td>
<td>Half-Life (Days)</td>
<td>Type</td>
<td>Decay Mode</td>
<td>Energy (MeV)</td>
<td>detection Method</td>
<td>Organs Affected</td>
<td>Radiation Source</td>
</tr>
<tr>
<td>-------------</td>
<td>-----------------</td>
<td>-------</td>
<td>---------------------</td>
<td>-----------------------</td>
<td>----------------------------</td>
<td>-----------------------------</td>
<td>---------------------------------------</td>
</tr>
<tr>
<td>Rb-86</td>
<td>18.66</td>
<td>Beta</td>
<td>Gamma Ray</td>
<td>1.7744 MeV Beta</td>
<td>Ion Chamber</td>
<td>Bone, Lung</td>
<td>Bremsstrahlung X-ray radiation when in high density materials</td>
</tr>
<tr>
<td>Sulfur-35</td>
<td>87.2</td>
<td>Beta</td>
<td>Gamma Ray</td>
<td>0.167 MeV Beta max, 0.06 average</td>
<td>Pancake GM tube</td>
<td>Skin dose, some internal risk</td>
<td>Plastic</td>
</tr>
<tr>
<td>Sr-90</td>
<td>30</td>
<td>Decay</td>
<td>Beta, Gamma Ray</td>
<td>2.27 MeV Beta max, 0.9 MeV Beta Aver</td>
<td>Bremsstrahlung X-ray radiation when in high density materials</td>
<td>GM tube or Ion Chamber</td>
<td>Internal (inhalation or ingestion) and external from X-rays</td>
</tr>
<tr>
<td>Tc-99m</td>
<td>6</td>
<td>Gamma</td>
<td>Gamma Ray</td>
<td>0.14 MeV</td>
<td>Ion Chamber</td>
<td>Whole body</td>
<td>Lead</td>
</tr>
<tr>
<td>Thallium-201</td>
<td>73</td>
<td>Gamma</td>
<td>Gamma Ray</td>
<td>0.1674 MeV</td>
<td>TI-202 contamination</td>
<td>Nervous system, extremities</td>
<td>Lead</td>
</tr>
<tr>
<td>Uranium</td>
<td>Essential forever</td>
<td>Alpha</td>
<td>from the U-238 decay chain</td>
<td>4-6 MeV</td>
<td>Scintillation counter</td>
<td>Still under review, central nervous system, kidneys</td>
<td>Plastic, must be isolated from oxygen environments</td>
</tr>
<tr>
<td>Yttrium-90</td>
<td>64</td>
<td>Beta</td>
<td>Gamma Ray</td>
<td>2.27 MeV Beta max, 0.9 MeV Beta Aver</td>
<td>Bremsstrahlung X-ray radiation when in high density materials</td>
<td>GM tube or Ion Chamber</td>
<td>Internal (inhalation or ingestion) and external from X-rays</td>
</tr>
</tbody>
</table>

Rb-86 (Rubidium) 18.66 Days Beta Gamma Ray 1.7744 MeV Beta 1.0766 MeV Gamma Bremsstrahlung X-ray radiation when in high density materials Ion Chamber Bone, Lung High density plastic, followed by lead outside

S-35 (Sulfur) 87.2 days Beta 0.167 MeV Beta max, 0.06 average Skin dose Pancake GM tube Skin dose, some internal risk plastic

Sr-90 30 years Decay Decays to Y-90 and is in equilibrium with it. 2.27 MeV Beta max, 0.9 MeV Beta Aver Bremsstrahlung X-ray radiation when in high density materials GM tube or Ion Chamber Internal (inhalation or ingestion) and external from X-rays High density plastic, followed by lead outside

Tc-99m (Technetium) 6 hours Gamma ray 0.14 MeV Ion Chamber Whole body lead

Thallium-201 (Thallium) 73 hours Gamma ray 0.1674 MeV Ti-202 contamination Ion Chamber Nervous system, extremities Lead

Uranium (Depleted) Essential forever Alpha from the U-238 decay chain. 4-6 MeV 99.3% U-238 0.7% U-235, may spontaneously combust under certain conditions Scintillation counter Still under review, central nervous system, kidneys Plastic, must be isolated from oxygen environments

Yttrium-90 (Yttrium) 64 hours Beta 2.27 MeV Beta max, 0.9 MeV Beta Aver Bremsstrahlung X-ray radiation when in high density materials GM tube or Ion Chamber Internal (inhalation or ingestion) and external from X-rays High density plastic, followed by lead outside
Appendix B
Radiation Safety Officer (RSO) notification references:

4. Cura, M, et al., Clinical Safety & Effectiveness Session # _1 Safe use of Radiation during Fluoroscopy Procedures, University of Texas Health Science Center at San Antonio, 2009 http://uthscsa.edu/cpshp/CSEProject/Safe%20use%20of%20Radiation%20during%20Fluoroscopy%20Procedures.pdf

The references [1, 2] indicate that main erythema occurs at ~6 Gy, so 5 Gy is just below that threshold.

Main erythematous phase: This corresponds clinically to a more severe reddening of the skin, and is usually associated with inflammatory reactions. It starts about 2 to 3 weeks after exposure. It may be painful (as a burn). Within a short time it may become associated with various degrees of skin desquamation, and possibly with pigmentation.

<table>
<thead>
<tr>
<th>Effect</th>
<th>Typical Threshold Absorbed Dose (Gy)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early transient erythema</td>
<td>2</td>
</tr>
<tr>
<td>Temporary epilation</td>
<td>3</td>
</tr>
<tr>
<td>Main erythema</td>
<td>6</td>
</tr>
</tbody>
</table>

Another reference [3] specifies 5 Gy as the threshold for patient follow-up. If air KERMA is not available then total fluoroscopy time of 60 minutes should be used as the threshold for patient follow-up.
References [4] specifies patient follow-up at 2 Gy, early transient erythema:

The Cardiac Catheterization Lab at the University of Rochester Medical Center uses 2 Gy for their internal notification threshold. Based on the above information, the Radiation Safety Officer (RSO) should be notified if the patient receives >5 Gy during a fluoroscopy procedure. If air KERMA is not available then total fluoroscopy time of 60 minutes should be used as the threshold for RSO notification. The RSO then would contact the notifying department to ensure patient follow-up and associated care of the skin is occurring. Patient exposure > 2 Gy must be recorded in RL solutions.
Appendix C
Radiation Exposure Policy

Policy for patients receiving extended fluoroscopy exposure at URMC

**Purposes:**

a. To establish a protocol for informing patients who have received skin exposure from fluoroscopy and may have higher potential for tissue injury.

b. To establish a protocol for assuring follow-up with these patients.

**Who:** Patients in URMC who have received greater than 2 Gy exposure (Air Kerma) from fluoroscopy in diagnostic and interventional procedures. The RSO is also notified, as per University Policy, of exposures greater than 5 Gy (or exposure time greater than 60 minutes when Air Kerma is unavailable.)

<table>
<thead>
<tr>
<th>Plan</th>
<th>Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Attending physician</strong></td>
<td>The attending physician will notify a Nurse Practitioner (NP), or a Cath/EP Advanced Practice Provider (APP) of any patient that has been exposed to an Air Kerma greater than 2 Gy. The procedure must be recorded in RL Solutions. If the Air Kerma value is unavailable then 60 minutes or more of fluoroscopy may be used as a reference value.</td>
</tr>
<tr>
<td><strong>NP or APP</strong></td>
<td>A follow-up appointment with the NP or APP will be scheduled for 30 days after the exposure.</td>
</tr>
<tr>
<td><strong>Radiation Oncology</strong></td>
<td>Any concerns regarding possible radiation injury will be directed to the attending physician. A Radiation Oncology provider, with radiation burn expertise, will be consulted.</td>
</tr>
<tr>
<td><strong>Radiation Safety Officer</strong></td>
<td>Will be contacted if the Air Kerma exceeds 5 Gy (or exposure time greater than 60 minutes when Air Kerma is unavailable).</td>
</tr>
</tbody>
</table>
REFERENCES
The following references are used in formulating the basis for the radiation safety within the University. All documents referenced in this manual are available in the Radiation Safety Unit’s Office (G-8842).

The RSU maintains subscriptions with the National Council on Radiation Protection and Measurements, the International Council on Radiation Protection, and the International Commission on Radiation Units and Measurements. The RSU receives periodic updates on standards issued by the Health Physics Society, the American Association of Physicists in Medicine, and the American National Standards Institute. Other references, guidance documents, and recommendations are ordered as necessary and available. These documents, recommendations, and reports are available from the RSU on request.

References
1. New York State Sanitary Code, Chapter 1, Part 16 and Appendix 16A
3. University of Rochester New York State Department of Health Radioactive Materials License #436
11. New York State Department of Environmental Conservation, Chapter IV, Subchapter C, Part 380, Prevention and Control of Environmental Pollution by Radioactive Materials.