RADIATION SAFETY MANUAL

Office of Radiation and Nuclear Safety
Department of Environmental Health and Safety
Division of Human Resources

December 2008

This document was prepared for users of laboratories and facilities at Rensselaer Polytechnic Institute utilizing radioactive materials and/or equipment which can produce ionizing radiations. The document is revised periodically and can be reviewed and downloaded from the University's website:

http://www.rpi.edu/dept/hr/forms/RPI Radiation Safety Manual.pdf

Comments and suggestions for improving the document, as well as the procedures and regulations contained within, are welcome and may be sent to caracp3@rpi.edu.

The New York State Department of Health's State Sanitary Code, Chapter I, Part 16, titled "Ionizing Radiation" is accessible at www.health.state.ny.us/. The Code of Federal Regulations, Title 10, Part 20, titled "Radiation Protection" for the US Nuclear Regulatory Commission is accessible at www.nrc.gov/. The NYS Department of Environmental Conservation website is available at www.dec.state.ny.us/.

Peter Caracappa, Ph.D., CHP
Radiation Safety Officer

Curtis Powell, SHRM
Vice President, Human Resources

TABLE OF CONTENTS

1. ALARA POLICY

The radiation dose received by any person from external or internal exposure to ionizing radiation in a radiation installation must be held to the lowest possible value consistent with effective use of the installation. A radiation installation occurs in a controlled area, using radioactive material or machines that generate ionizing radiation. Exposure of personnel and the general public to ionizing radiation must never exceed the legal maximum permissible values.

Rensselaer's radiation protection guidance sets forth a dose limitation system based on three principles. These principles are:

> ***Justification***- There should not be any occupational exposure of persons to ionizing radiation without the expectation of an overall benefit from the activity causing the exposure;
>
> ***Optimization***- A sustained effort should be made to ensure that collective, annual, committed, and cumulative lifetime doses are maintained as low as reasonably achievable (ALARA) with economic and social factors being taken into account; and
>
> ***Limitation***- Radiation doses received as a result of occupational exposure should not exceed the specified limiting values contained in the New York State Department of Health (NYSDOH) Sanitary Code, Chapter 1, Part 16, titled "Ionizing Radiation".

Every effort should be made in order to avoid contamination of work areas and, in any case, release of airborne or waterborne radioactivity should never exceed legal limits. Every effort should be made to avoid accidental releases. Disposal of all radioactive waste must be in accordance with procedures contained in Section 5.

The radiation dose received by any person from external and/or internal exposure to ionizing radiation in a non-controlled area must be held as close to natural background levels as possible. Exposure to the general public from any operation must never exceed the annual legal maximum permissible exposure level of 100 mrem per year above the natural background level.

Legal maximum permissible dose levels are those specified in the current edition of the New York State Department of Health Sanitary Code, Chapter I, Part 16, titled "Ionizing Radiation". Also, the legal maximum permissible dose levels are specified in Title 10, Part 20 of the Code of Federal Regulations (10 CFR 20), titled "Radiation Protection". These two reference materials contain definitions of terms used in this document. Due to their size and the frequency with which they change, the federal and state regulations are stand-alone documents. However, these regulations are considered to be part of Rensselaer's Radiation Safety Regulations and Procedures outlined within this document. Copies of these and other pertinent documents are available from the Office of Radiation and Nuclear Safety (ORNS).

1.1 ALARA Program

Control of ionizing radiation exposure is based on the assumption that any exposure involves some risk. However, occupational exposure within accepted limits represents a very small risk compared to the other risks voluntarily encountered in other work environments.

The policy of Rensselaer Polytechnic Institute is to maintain occupational exposures of individuals to be within allowable limits as are defined by New York State Sanitary Code Part 16. The individual and collective dose to workers in maintained as low as reasonably achievable (ALARA).

ALARA is a part of the normal work process where people are working with ionizing radiation. Management at all levels, as well as each individual worker, must take an active role in minimizing this radiation exposure.

1.1.1 ALARA Practices

This is not an exhaustive list, but some of the most common practices that allow exposures to remain ALARA include:

1. Utilizing permanent or temporary shields as necessary to minimize the strength of a radiation field.

2. Minimizing time spent in a radiation area to only that necessary to complete a task.

3. Placing as much distance as possible between the user and the radiation source, while still allowing for a reasonable closeness to utilize the radiation.

4. Decontaminating areas of radioactive contamination before proceeding to the next task.

5. Using engineering controls to maintain radiation exposures to low levels.

6. Ordering and using only necessary amount of radioactive materials for an experiment.

7. Making sure all users have had proper training in the safe use of ionizing radiation.

1.2 Radiation Dose Limits

1.2.1 Radiation Workers

- "Radiation Workers" are any individuals (faculty, staff, student, or other) that are designated to work with sources of radiation, and have received training in safe use of radiation.
- The Total Effective Dose Equivalent (TEDE) or whole-body dose for radiation workers shall not exceed 5 rem per year.
- The dose to the eye shall not exceed 15 rems per year.
- The shallow dose equivalent to the skin and extremities shall not exceed 50 rem per year.

1.2.2 Pregnant Workers

Radiation workers that become pregnant while working with radiation in any form shall be limited to a dose of 500 mrem/gestational period of the fetus. Policies regarding pregnant workers are described in section 9.

1.2.3 Minors

Radiation workers under the age of 18 will be subject to dose limits that are 10% of those listed under "Radiation Workers" above. Parental permission is required for minors that are designated as radiation workers.

1.2.4 Members of the Public

Any person, internal or external to Rensselaer, that is not designated as a radiation worker is considered a member of the public. This includes inspectors, casual visitors, maintenance personnel, tour members, etc. Members of the public are limited to a whole-body dose of 100 mrem per year.

2. GLOSSARY

Absorbed dose – The energy imparted by ionizing radiation per unit mass of irradiated materials. The units of absorbed dose are the gray (Gy) and the rad.

Accelerator – Any machine capable of accelerating electrons, protons, deuterons, or other charged particles in a vacuum and also capable of discharging the resultant particulate or other radiation into a medium at energies usually in excess of one million electron volts (MeV).

Accelerator-produced material – Any materials made radioactive by a particle accelerator.

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

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

As Low As Reasonably Achievable (ALARA) – Making every reasonable effort to maintain exposure to radiation as far below the dose limits defined by law as is practical, consistent with the purpose for which the licensed or registered activity is undertaken, and taking into account the state of technology, the economics of improvements in relation to the 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 or registered sources of radiation in the public interest.

Attenuation – The process by which radiation is reduced in intensity when passing through some material. It is the combination of absorption and scattering processes.

Authorization – The approval issued to an individual by the Radiation and Nuclear Safety Committee to use and supervise the use of radioactive materials.

Authorized User – The individual authorized by the Radiation and Nuclear Safety Committee to use and supervise the use of radioactive materials. Typically, the Authorized User is a senior investigator or faculty member who has the primary scientific, financial, and legal responsibility for a research program. The Authorized User may use the authorized radiation sources directly or, with the approval of the Radiation and Nuclear Safety Committee, may delegate the operational responsibilities to a qualified user. The Authorized User has primary responsibility for radiation safety in facilities under his or her control.

Background radiation – Radiation from cosmic sources; naturally occurring radioactive materials, including radon (except as a decay product of source or special nuclear material) and global fallout as it exists in the environment from the testing of nuclear explosive devices.

Becquerel – SI unit of activity. One becquerel (Bq) is equal to one disintegration (transformation) per second (dps or tps).

Bioassay – Also known as radio bioassay; determination of kinds, quantities, or concentrations and, in some cases, the locations of radioactive materials in the human body, whether by direct measurement (in vivo counting) or by analysis and evaluation of materials excreted or removed from the human body.

Calibration – The determination of the response or reading of an instrument relative to a series of known radiation values over the range of the instrument; The determination of the strength of a source of radiation relative to a standard.

CFR – Code of Federal Regulations.

Committed effective dose equivalent – The dose equivalent to organs or tissues of reference that will be received from an intake of radioactive material by an individual during the fifty year period following intake.

Contamination – The deposition of unwanted radioactive material on the surfaces of structures, areas, objects, or personnel. Can either be fixed or removable.

Cumulative dose – The total dose resulting from repeated exposures of radiation to the same region, or to the whole body, over a period of time.

Curie – A unit of quantity of radioactivity; One curie (Ci) is that quantity of radioactive material which decays at the rate of 3.7×10^{10} disintegrations (transformations) per second (dps or tps).

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

Decontamination – The reduction or removal of contaminating radioactive material from a structure, area, object, or person

Deep dose equivalent – Dose equivalent from external radiation at a tissue depth of one centimeter; Also known as **whole body dose**

Disintegration – The decrease in the amount of any radioactive material with the passage of time, due to the spontaneous emission from the atomic nuclei of either alpha particles, beta particles, or gamma rays; Also known as **radioactive decay**

Dose – Either absorbed dose, dose equivalent, or effective dose equivalent.

Dose equivalent – The product of the absorbed dose in tissue, quality factor, and all other necessary modifying factors (e.g., a distribution factor for non-uniform deposition) at the location of interest. The units of dose equivalent are the sievert (Sv) and the rem.

Dose limits – The permissible upper bounds of radiation doses.

Dose rate – The dose per unit of time; see also **exposure rate**

Effective dose equivalent – The sum of the products of the dose equivalent to each organ or tissue and the weighting factor applicable to each of the organs or tissues that are irradiated.

Embryo/fetus – The developing human organism from conception until the time of birth.

Exposure – A measure of the ionization produced in air by x or gamma radiation; Irradiation by ionizing radiation or radioactive material; Unit of exposure is the Roentgen (R).

Exposure rate – The exposure per unit of time; see also **dose rate**

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

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

Eye dose equivalent – Also known as lens dose equivalent; The external dose equivalent to the lens of the eye at a tissue depth of 0.3 centimeters.

Gray – SI unit of absorbed dose; One gray is equal to an absorbed dose of one joule per kilogram; Also, one gray is equal to one hundred rad.

Half-life – The time in which half the atoms of a particular radioactive substance disintegrate to another nuclear form. Measure half lives vary from millionths of a second to billions of years. Also referred to as the physical half-life.

High radiation area – Any area accessible to individuals in which radiation levels from radiation sources external to the body could result in an individual receiving a dose equivalent in excess of one mSv (0.1 rem) in one hour at thirty centimeters from any source of radiation or from any surface that the radiation penetrates.

Ionizing radiation – Gamma rays, x-rays, alpha particles, beta particles, high-speed electrons, neutrons, protons, and other nuclear particles, or electromagnetic radiations capable of producing ions directly or indirectly in their passage through matter; Does not include sound or radio waves, or visible, infrared, or ultraviolet light.

Member of the public – Any individual, except an individual who is performing assigned duties for the licensee or registrant involving exposure to sources of radiation.

Minor – An individual less than eighteen years of age.

Monitoring – Also known as radiation monitoring or radiation protection 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.

Non-ionizing radiation – Radiation that does not produce ionization. Examples are sound, radio waves, visible, infrared, and ultraviolet light.

Occupational dose – The dose received by an individual in the course of employment in which the individual's assigned duties for the licensee or registrant involve exposure to sources of radiation. Occupational dose does not include dose received from background radiation, from any medical administration the individual has received, or as a member of the public.

Rad – Unit of absorbed dose; One rad is equal to an absorbed dose of one hundred ergs per gram or 0.01 joule per kilogram.

Radiation area – An 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 one hour at thirty centimeters from the source of radiation or from any surface that the radiation penetrates.

Radiation emergency – The uncontrolled release of radioactive material from a radiation installation which poses a potential threat to the public health, welfare, and safety.

Radiation installation – Any location or facility where radiation machines are used or where radioactive material is produced, transported, stored, disposed or used for any purpose, except where such radioactive materials or facilities are subject to regulation by the Nuclear Regulatory Commission.

Radiation Producing Equipment – Any device that produces radiation when in use, except those which produce radiation only from radioactive materials.

Radiation Safety Officer – An individual who has the knowledge and responsibility to apply appropriate radiation protection regulations and has been assigned such responsibility by the licensee or registrant.

Radioactive material – Any solid, liquid, or gaseous substance which emits radiation spontaneously.

Radioactive waste – A solid, liquid, or gaseous material from experimental/research operations that is radioactive and for which there is no further use.

Radioactivity – The disintegration (transformation) of unstable atomic nuclei by the emission of radiation.

Rem – The special unit of any of the quantities expressed as dose equivalent. The dose equivalent in rem is equal to the absorbed dose in rad multiplied by the quality factor; also, one rem equals 0.01 Sv.

Roentgen – The special unit of exposure. One roentgen (R) equals 2.58×10^{-4} coulombs per kilogram.

Restricted area – An area, access to which is limited by the licensee for the purpose of protecting individuals against undue risks from exposure to radiation or radioactive materials. Restricted area does not include areas used as residential quarters, offices, etc.

Sealed source – Any device containing radioactive material to be used as a source of radiation which has been constructed in such a manner as to prevent the escape of any radioactive material.

SI – The abbreviation for 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 gray multiplied by the quality factor; Also, one sievert equals one hundred rem.

Special nuclear material – Plutonium, uranium-233, uranium enriched in the isotope 233 or in the isotope 235, and any other material which is declared by order to be special nuclear material after the U.S. Nuclear Regulatory Commission, or any successor thereto, has determined the material to be such, but does not include source material; any material artificially enriched by any of the foregoing, but does not include source material.

Survey – An evaluation of the radiological conditions and potential hazards incident to the production, use, transfer, release, disposal, or presence of sources of radiation. Such an evaluation includes, but is not limited to, measurements or calculations of levels of radiation, or concentrations or quantities of radioactive material present.

Very high radiation area – An area accessible to individuals in which radiation levels from radiation sources external to the body could result in an individual receiving an absorbed dose in excess of five Gy (five hundred rad) in one hour at one meter from a source of radiation or from any surface that the radiation penetrates.

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

Worker – Any individual engaged in work under a license or registration issued by the department and controlled by a licensee or registrant, but does not include the licensee or registrant.

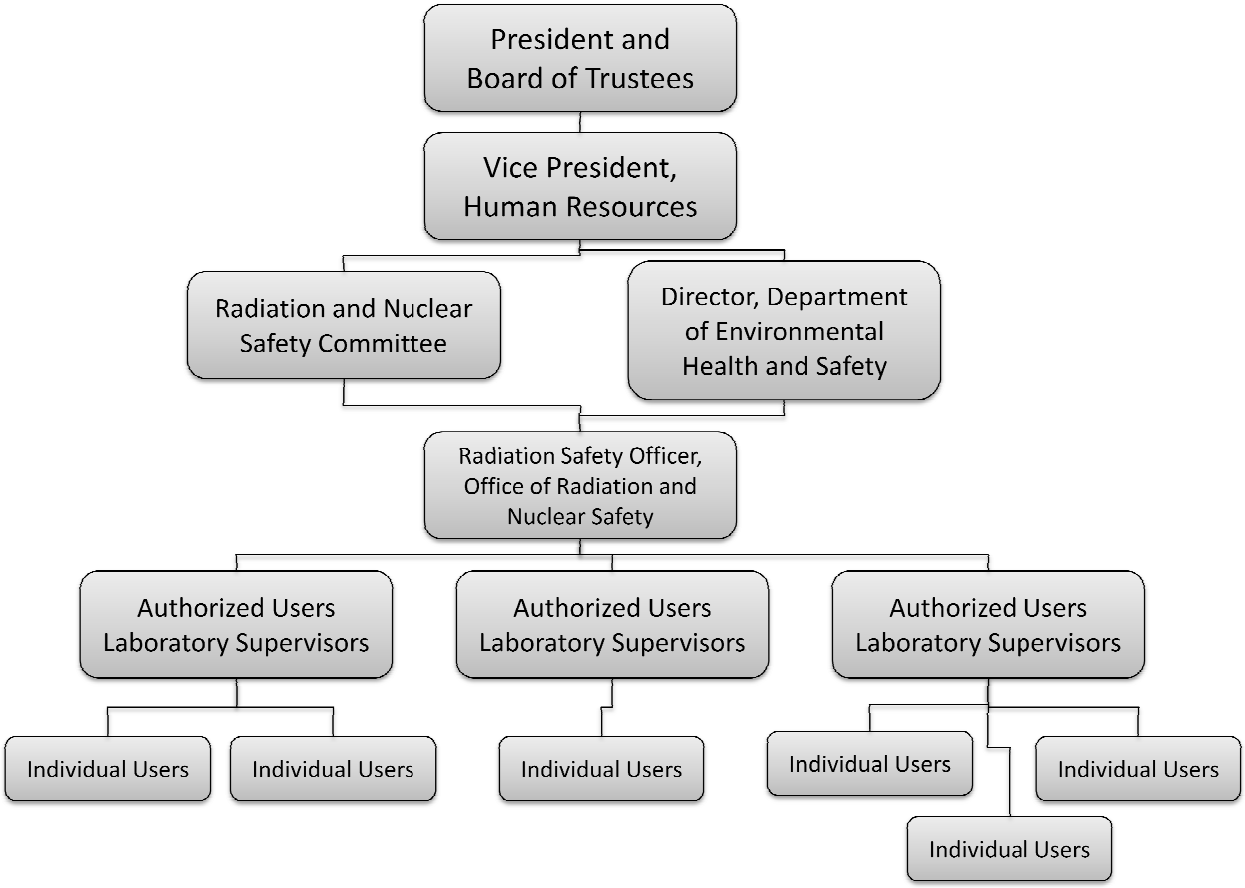
3. FUNCTIONS AND RESPONSIBILITIES

The Office of Radiation and Nuclear Safety reports to the Department of Environmental Health and Safety, which in turn reports to the Vice President of Human Resources, who acts as the representative of the President and the Board of Trustees.

The Radiation and Nuclear Safety Committee, which also reports to the Vice President of Human Resources, is composed of both faculty and staff personnel.

3.1 Organization Chart

The following chart shows the current organization of Rensselaer's radiation safety program.



3.2 Radiation and Nuclear Safety Committee

3.2.1 Membership

The Radiation and Nuclear Safety Committee is appointed by and reports to the Vice President of Human Resources. Membership in the Committee should include:

- Representatives of the faculty in each academic department that has users of radioactive material and/or radiation producing equipment. These members should have experience in the use of radioactive materials, the use of radiation producing equipment, or in some aspect of radiation safety.
- Representatives of administrative departments or divisions that may be impacted by or contribute to activities involving sources of radiation.
- A representative of the RPI Management
- The Radiation Safety Officer, who also serves as the committee secretary

The Chairperson of the committee is selected from among the faculty representatives on the committee, and approved by the committee membership.

All appointments to the Radiation and Nuclear Safety Committee and the selection of a chairperson must be submitted to and approved by the New York State Department of Health.

3.2.2 Responsibilities

The Committee is responsible for:

- Ensuring that all individuals who work with or in the vicinity of radioactive material have sufficient training and experience to enable them to perform their duties safely and in accordance with Department regulations and the conditions of this license.
- Ensuring that all use of radioactive material is conducted in a safe manner and in accordance with Department regulations and the conditions of the license.

The committee's duties include:

1. Setting Institute policies for radiation and nuclear safety.

2. Giving such advice and assistance as may be requested by the RSO.

3. Giving approval to reactivate an operation involving radiation if such an operation has been stopped by the RSO.

4. Evaluating the Institute's overall radiation safety program and the effectiveness of the administration of this program on an annual basis. Evaluation results should be presented in a brief written annual report to the Vice President of Human Resources.

5. Reviewing the adequacy of the training and experience of Authorized Users to possess and use radioactive material and radiation sources under the Institute licenses.

6. Monitoring the institution's program to maintain individual and collective doses as low as reasonably achievable (ALARA), and review, with the assistance of the Radiation Safety Officer, occupational radiation exposure records of all personnel working with radioactive materials.

7. Participating in an annual review of the Radiation Safety Program, in conjunction with the Radiation Safety Officer.

8. Being familiar with all pertinent New York State Health Department regulations, the terms of the license, and information submitted in support of the request for the license and its amendments.

9. Establishing a program to ensure that all individuals whose duties may require them to work in the vicinity of radioactive material (e.g., security and housekeeping personnel) are properly instructed as required by Section 16.13, New York State Sanitary Code (10 NYCRR 16).

10. Reviewing and approving all requests for use of radioactive material within the institution.

11. Proscribing any special conditions that will be required during a proposed use of radioactive material such as requirements for bioassays, physical examinations of users, and special monitoring procedures.

12. Recommending remedial action to correct any deficiencies identified in the radiation safety program.

13. Maintaining written records of all Committee meetings, actions, recommendations, and decisions.

The chairperson of the committee has various responsibilities, including:

1. Calling meetings of the committee

2. Making recommendations to the Vice President of Human Resources concerning the size and composition of the committee.

3. Preparing reports of committee activities for the Vice President of Human Resources.

3.2.3 Meetings

The committee meets at least four times a year, nominally twice during the fall semester and twice during the spring semester. The committee may also be called at any time during the calendar year whenever matters of urgency arise, as determined by the Vice President of Human Resources, the chairperson, or the RSO. Guests may attend meetings at the invitation of the chairperson. In the event that meetings are held in the absence of the chairperson, a chairperson pro tempore will be selected from the attending members.

A quorum consists of at least half of the Committee members and must include the Radiation Safety Officer and the Management Representative.

Minutes of meeting are distributed to the members, the Vice President of Human Resources, the staff of the Office of Radiation and Nuclear Safety, and to the Chairperson of the Nuclear Safety Review Board.

3.3 Office of Radiation and Nuclear Safety and the Radiation Safety Officer

The Office of Radiation and Nuclear Safety was established to facilitate implementation of Institute policy and procedures on radiation safety. The Office consists of the Radiation Safety Officer, and may also include part-time student workers and/or staff time from the Department of Environmental Health and Safety. The Office has the necessary instrumentation for surveillance of sources of ionizing radiation on campus and provides a periodic appraisal and radiation surveys for Rensselaer's radiation installations.

The RSO has the authority to stop an operation of any kind if a radiation hazard to personnel exists, if the Institute's property is endangered, or if neglect of the Institute policies is observed. The RSO is an ex officio member of the Radiation and Nuclear Safety Committee and the Nuclear Safety Review Board.

The Radiation Safety Officer shall:

- Supervise radiation control activities.
- Have the authority to halt operations involving radioactive material or radiation machines if unsafe or unacceptable conditions exist.
- Determine compliance with policies issued by the Committees and by Federal, State and Local agencies.
- Carry out the policies and recommendations concerning radiation and nuclear safety established by the Radiation and Nuclear Safety Committee throughout the Institute.
- Investigate all proposals for the use of radioactive material and radiation-producing devices and conditions of their use and transmit such proposals to the Radiation and Nuclear Safety Committee with recommendations for approval or disapproval.
- Prepare an annual report for the radiation safety program to be presented to the Radiation and Nuclear Safety Committee.
- Keep the Radiation and Nuclear Safety Committee informed of any significant changes in government regulations on radiation safety, licensing and registration, and provide the committee with copies of relevant documents.
- Control acquisition and transfers of radioactive materials to individuals on and off campus and ensure that individual and institutional possession limits are not exceeded.
- Maintain accountability records for all special nuclear materials.
- Prepare license amendments, permit applications and maintain timely renewals of licenses and permits.

- Register all radiation producing machines with NYSDOH.
- Respond to emergencies and supervise decontamination or other response activities.
- Manage the programs for providing radiation safety training to individual users, ancillary workers and Public Safety personnel.

Additionally, it shall be the responsibility of the Office of Radiation and Nuclear Safety to:

- Maintain radiation dosimetry records of all persons issued personnel monitors and maintain records of bioassay results.
- Maintain a registry of all campus facilities subject to the radiation safety program.
- Maintain records of radioisotope procurement and disposal
- Assist users in the storage, use and disposal of radioactive material at the laboratory level.
- Perform periodic inspections of laboratories using radiation producing equipment and/or radioactive material and make recommendations for improvement of conditions to conform to Institute policies.
- Coordinate the radioactive waste management program, including receipt of waste, decay-in-storage, burial, incineration and disposal through commercial vendors.
- Calibrate radiation survey instruments for Authorized Users when required.
- Perform leak tests on sealed sources as required by State regulations.
- Receive, inspect and distribute incoming shipments of radioactive materials.

3.4 Authorized Users

The Authorized User is the individual with the primary responsibility for safe use of sources of radiation in one or more installations.

The procedure for designation of Authorized Users, and for specific Authorizations, is contained in RPP-3 in the Radiation Procedures Manual. Further information on establishment of Authorization is available in that procedure.

3.4.1 Qualifications

An applicant for radioisotope use shall be a full-time member of the faculty and have both training and experience commensurate with the types and quantities of radioactive material for which application is being made. If a faculty member does not have the appropriate experience to be designated an Authorized User, he or she may designate an appropriate individual to serve as a mentor in order to obtain approval.

Each Authorized User may have one or more authorizations under his or her responsibility.

3.4.2 Designation of a Laboratory Supervisor

In some situations, it may be appropriate for an Authorized User to designate a Laboratory Supervisor to take on the day-to-day responsibility for oversight of radiation safety practices and procedures in the laboratory. Appropriate situations may include a complex facility, an Authorized User with significant administrative duties, or an Authorized User on a sabbatical. Although many duties may be delegated to a Laboratory Supervisor, the Authorized User maintains the primary responsibility for the safety of the lab.

A Laboratory Supervisor may be a faculty member, staff member, post-doctoral researcher, or similar individual, but generally should not be a full-time student. Designation of a Laboratory Supervisor should be made in writing, and requires the approval of the Radiation Safety Officer.

3.4.3 Responsibilities

- Ensure that all users of the installation maintain a day-to-day radiation safety program within their assigned spaces in compliance with Institute policies. The term "users" refers to all persons who work in the installation, including the supervisor, postdoctoral associates, graduate students, undergraduate students, and technicians. It also applies to students using the installation for a laboratory course or for a research project.

- Notify the RSO of any "reportable occurrences" immediately and within three days provide a written report of the occurrence to the RSO. Reportable occurrences shall include:
    - Any incident involving the use of radioactive materials exceeding ten μCi beta-gamma emitters or one μCi of alpha emitters.
    - Any incident suspected of exceeding a radiation dose of 125 mRem in one calendar quarter to any part of the body.
    - Any incident suspected of causing the release of radioactive material to the breathing environment of personnel.
    - The accidental release of radioactive materials to the sanitary sewer or the exhaust duct system of fume hoods.
    - The loss of any radioactive material, radioactive source, or special nuclear material.

- Maintain a comprehensive inventory of the sources of ionizing radiation (radionuclides and machines that produce ionizing radiation) in the installation.

- Ensure that any person using material or equipment is properly qualified and has received radiation protection training.

- Ensure that proper personnel monitoring equipment is worn by personnel, visitors, and the supervisor.

- Keep the RSO informed of the scope and proposed changes in the program.

- Notify the coordinator of Physical Facilities by a note on the work order and the RSO when work is to be done in an area where radioactive materials or radiation generating equipment is stored or used.

- Ensure that no eating, drinking, or applying cosmetics occur in the laboratories.

- Develop written procedures for the use of radiation sources or radioactive material as appropriate for the intensity and scope of the activities covered in the Authorized User's laboratory and commensurate with good radiation protection practices.

- Furnish all information requested by the Committee or Radiation Safety Officer concerning his/her qualifications, facilities, equipment and safety procedures.

- Maintain records as required by this Manual.

- Comply with the applicable portions of this Manual to the best of his/her ability.

- Notify the Radiation Safety Officer of any changes in authorization status.

3.4.4 Establishment of Authorizations

Authorizations are established as outlined in RPP-3. Each Authorized User is required to develop a set of written procedures that are specific to his/her laboratory. Laboratory-specific Standard Operating Procedures give the individual Authorized Users autonomy in determining the day-to-day conduct of radiation protection procedures in their laboratories, based on the nature of their use of radioactive material and/or radiation-producing devices.

If the Authorized User wishes to alter the conditions of the authorization (such as by adding or deleting permitted radionuclides or devices, changing locations of use or changing possession limits), prior approval is required. Minor changes may be approved directly by the Radiation Safety Officer, while major changes require review by the Radiation and Nuclear Safety Committee. The Radiation Safety Officer will make the determination in accordance with RPP-3.

3.5 Individual Users

The most important responsibility for radiation safety rests with the individual users. Individual users shall:

- Understand and implement the appropriate radiation safety precautions for the specific radioactive nuclide(s) being used.
- Conduct operations so as to minimize exposure (internal and external) to all personnel in the laboratory.
- Wear a personnel monitor as instructed.
- Periodically survey his/her hands, feet and clothing, and the work area for contamination.
- Periodically survey around storage and waste areas.

4. RADIOACTIVE MATERIALS

For the purposes of this section, the term "radioactive materials" does not include radioactive material contained in sealed sources, which is addressed separately in Section 6.

4.1 General Safe Rules for Use of Radioactive Material

- High standards of cleanliness and good housekeeping must be maintained in all laboratories and areas where radioactive material is present. Eating, drinking and smoking in a work area is prohibited. Do not store food, drink, or personal effects with radioactive material.

- Whenever practicable, operations with radioactive materials should be conducted in a limited designated area. Operations with materials susceptible to atmospheric contamination, such as boiling, evaporating, distilling, or ashing must be done in a hood approved by the Rensselaer fume hood certification program. Work with powders shall be done in a dry box. Work with unsealed radioactive materials should be done over a tray.

- Work which may result in contamination of work surfaces shall be done over plastic-backed absorbent paper. Trays made of impervious materials (i.e., stainless steel, porcelain-coated, etc.) and lined with absorbent paper provide excellent work arrangements to help prevent the spread of contamination.

- Lab coats and disposable gloves shall be worn during operations involving the handling of unsealed sources of radioactive material. The lab coat and gloves should be removed before leaving the laboratory. Care must be taken such that other items (e.g., pens, pencils, notebooks, door knobs, telephones, etc.) are <u>not</u> handled with gloves used during work with radioactive materials.

- No radioactive solution is ever to be pipetted by mouth. Suitable pipetting devices must be available and used by the person working with the radioactive solution. Segregate pipetting devices used with radioactive materials from those used with nonradioactive solutions.

- If personnel monitoring devices (whole-body or ring badge) have been issued for work with radioactive material, they must be worn at all times when in areas where these materials are used or stored. These devices should be worn as prescribed by the Radiation Safety Officer. Personnel monitoring devices should be stored in a designated low background area when they are not being worn to monitor occupational exposures. They should <u>not</u> be left on your lab coat or shared by another individual.

- Any contamination of the body or clothing by radioisotopes must immediately be reported to the RSO. Accidental contamination of any working area must be clearly marked as to the radioisotope, the area, and the survey meter reading. Decontamination shall proceed as soon as practicable.

- After working with unsealed sources of radioactive material, hands should be monitored with a suitable instrument (GM type for beta-gamma emitters and/or alpha-sensitive meter for alpha emitters) and washed before leaving the laboratory. No person or object shall leave the laboratory without being monitored and properly decontaminated, if necessary, to assure no spread of contamination or personnel radiation exposure.

- When work is completed, each person must assure that his work area and apparatus are surveyed, cleaned up, and arranged for disposal or proper storage of all radioactive materials and equipment.

- Store radioactive materials in covered containers plainly identified with "Caution – Radioactive Materials" and labeled with name of compound, radionuclide, date, activity, and radiation level, if applicable.

- Proper containers shall be used for storage of radioactive waste. Liquid waste shall be stored separately from solid waste. Dispose of radioactive waste only in the manner designated by the Radiation Safety Officer and maintain records as instructed

- Objects and equipment that may have been contaminated with radioactive material shall be surveyed and demonstrated to be free of contamination prior to their removal from a laboratory, or transferred to other laboratories, repair shops, surplus, etc. If found to be contaminated, such items must be decontaminated as soon as practical.

4.2 Procurement of Radioactive Materials

No sources of radiation (machines or radioactive materials) may be brought to the Rensselaer campus without prior approval of the Office of Radiation and Nuclear Safety. All purchases and approvals are processed through the OSCAR purchase requisition system. Instructions on using OSCAR are available from the Purchasing Department at Rensselaer.

Purchases may only be requested through the use of a purchase requisition. Credit card and "punch-out" catalog orders may not be used for radioactive materials. Under "Special Approvals," the box marked "Radioactive" must be checked prior to submitting the order. This will automatically direct the order to the Office of Radiation and Nuclear Safety for approval.

Purchases of radioactive materials must be directed to the following address:

Office of Radiation and Nuclear Safety
ATTN: Radiation Safety Officer
Cogswell Stockroom, Room 219
110 8th Street
Troy, NY 12180-3590

For sufficient purpose, an alternate delivery location may be approved by the Radiation Safety Officer on a case-by-case basis.

In the rare instance where radioactive material is obtained outside of the context of a purchase (sample, gift, etc.), a written request detailing the isotope, activity, and form must be sent to the Radiation Safety Officer and approved before radioactive material is transferred to Rensselaer.

4.3 Radioactive Materials Package Receiving

When purchased radioactive material arrives at Rensselaer, it is delivered to the Chemical Stockroom in Cogswell 219 (or an approved alternate location) for inspection by the Office of Radiation and Nuclear Safety.

Inspection of received packages is performed according to the procedure entitled "Opening of Packages Containing Radioactive Materials" in the Procedure Manual.

4.4 Transportation of Radioactive Material

Transportation of radioactive material between locations on the Rensselaer campus may be performed either by hand or by Rensselaer vehicle. Transportation in privately owned vehicles is forbidden.

Transportation or shipment of material to off-campus locations may be performed only by common carrier. Packages shall be inspected by ORNS staff prior to shipment for compliance with Department of Transportation regulations.

4.4.1 Hand Transport

Hand transport of radioactive materials should take place only with an appropriate container to minimize the possibility of contamination and the exposure to personnel and passers-by. In particular, an appropriate container is either:

- The closed, original shipping container for the material.
- A container with a secure latch that will remain closed if accidentally dropped from normal carrying height.
- A container specifically approved by the Radiation Safety Officer for the transportation of radioactive material.

Containers with an exposure rate of less than 2 mR/hour at a distance of 1 meter may be transported on campus without establishing area controls. The material shall be moved directly between approved storage/use locations and not permitted to linger in unapproved areas. Packages that exceed 2 mR/hour at a distance of 1 meter may require access control of the travel pathway, and shall be conducted only under the direction of the Radiation Safety Officer.

4.4.2 Vehicular Transport

Transportation in Rensselaer vehicle shall be performed only by ORNS staff, and in accordance with US Department of Transportation and New York State Department of Environmental Conservation regulations.

5. WASTE DISPOSAL

5.1 Dry Solid Waste

Dry solid waste consists of materials and laboratory waste such as gloves, absorbent paper, and used lab equipment which is or may be contaminated with radioactive materials. No freestanding liquids, sharps lead, or other hazardous materials should be placed into dry solid waste containers.

Radioactive waste should be stored in sturdy containers that are not so large that full containers become too heavy to lift. Plastic five-gallon pails work well for this purpose. The outside of the container should be clearly labeled with "Caution – Radioactive Waste" or "Caution – Radioactive Materials" and the isotope it contains. Hazardous waste labels should not be used for radioactive wastes.

The waste storage container should be lined with a removable plastic liner at least 4 mil (0.1 mm) thick. The bag itself should not be marked or labeled with the radiation warning symbol.

Radioactive waste should be segregated into separate waste containers for each isotope. If an experiment generates waste containing more than one isotope, the waste material should be placed into the container for the material with the longest half-life.

Any items bearing the radiation warning symbol or the word "radioactive" must have those labels removed, covered, or ablated before disposal in dry solid waste containers. Also, any biohazard symbols or markings should be removed from items placed into dry solid waste.

When a dry solid waste container is full, the bag should be sealed and marked with the date it is closed, the isotope, the estimated activity, and the laboratory of origin. Contact the Office of Radiation and Nuclear Safety to arrange for transfer of the material to the Blaw Knox storage facility.

5.2 Radioactive Sharps

Radioactive sharps are hazardous items that require special precautions and handling. If the following items have come into contact with radioactive material, dispose of them in containers specifically designed for sharps and that bear a "Caution – Radioactive Material" label listing the isotope and date:

- Needles and syringes
- Pasteur pupettes
- Scalpels and razor blades
- Microscope slides and coverslips
- Glassware that cannot be decontaminated

Sharps containers are closable, puncture resistant, leak-proof on the sides and bottoms, and are typically available in various sizes. Red biohazard sharps containers *must not* be used for radioactive sharps that would not otherwise be considered biohazard waste.

When a sharps container is full, label it with the date of closure, estimated activity, and laboratory of origin, and contact the Office of Radiation and Nuclear Safety for disposal.

5.3 Liquid Waste

5.3.1 Sanitary Sewer Disposal

Disposal of radioactive material via the sanitary sewer is permitted under specific circumstances. Disposal via sanitary sewer must be part of the approved lab protocol. No disposal may be done without prior notice.

Only material that is readily soluble in water may be disposed of into the sanitary sewer. The solubility class of a compound can be determined from common literature (e.g. Handbook of Chemistry and Physics, etc.). If a compound is classified as "very soluble" or "soluble," this would indicate the compound is "readily soluble."

Disposal is allowed *only* for Tritium (Hydrogen-3), Carbon-14, Phosphorus-32, Phosphorus-33, Sulfur-35, and Chlorine-36.

No materials that may be classified as hazardous waste may be disposed via sanitary sewer.

Each lab is limited to disposal of 2.5 millicuries per month of each nuclide (except for tritium, which is limited to 25 millicuries per month).

A disposal log is required, which includes the date, radionuclide, and estimate of the total activity disposed. This log should be posted in the lab and made available to the Radiation Safety Officer upon request.

5.3.2 Bulk Liquid Wastes

Liquid waste that does not qualify for sanitary sewer disposal must be disposed of as bulk liquid waste. Bulk liquid waste must be stored in plastic containers (or glass if necessary for chemical compatibility), with a securely fitting top. The container must remain closed except when in use.

The outside of the liquid waste container should be labeled with "Caution – Radioactive Materials" and the isotope contained. Do not use hazardous waste labels on liquid radioactive waste containers, unless the material is also a hazardous waste (see "Mixed Wastes").

Liquid waste should be segregated by chemical type and by isotope. No material other than liquids will be placed in liquid waste containers.

Liquid waste containers should be kept inside a secondary container which would contain all radioactive materials should the liquid waste container be damaged or break.

When a liquid waste container is full, the container should be marked with the date it is closed, the isotope, the estimated activity, and the laboratory of origin. Contact the Office of Radiation and Nuclear Safety to arrange for transfer of the material to the appropriate storage and/or disposal facility.

5.4 Liquid Scintillation Material

Hazardous (xylene or toluene based) liquid scintillation cocktail is not permitted at RPI. Scintillation cocktail should bear the words "biodegradable" or "non-hazardous" or similar language. Contact the Office of Radiation and Nuclear Safety if you are unsure.

Liquid scintillation vials should be capped tightly for disposal and not emptied. The disposal of the vials depends upon its contents:

1. Carbon-14 or tritium at less than 0.05 μCi/mL: These vials can be disposed of in regular trash. They should not bear any radioactivity markings. For guidance based upon conservative estimates, you can assume that a vial meets the 0.05 μCi/mL standard if it is measured at less than 70,000 cpm/mL of cocktail in a vial.
2. Any other vials: Segregate by isotope into sturdy containers. When full, mark with the date closed, isotope, and laboratory of origin and contact the Office of Radiation and Nuclear Safety for disposal.

5.5 Mixed Wastes

Mixed wastes are defined as wastes that contain radioactive materials and a hazardous waste. These types of wastes require special handling. Researchers are encouraged to minimize the generation of mixed wastes because of the large expense for disposal of these wastes.

This is not an exhaustive list, but radioactive wastes that contain any of the following must generally be handled as a mixed waste:

Solvents (e.g. methanol, methylene chloride, acetone, etc.)	Carbon Tetrachloride
Flammable chemicals	Chlordane
Nitrates	Chlorobenzene
Sulfides	Chloroform
Cyanides	O-Cresol
Aqueous solutions with pH $\leq$ 2 or $\geq$ 12.5*	M-Cresol
Arsenic	P-Cresol
Barium	1,4-Dichlorobenzene
Cadmium	1,1,-Dichloroethylene
Chromium	2,4-Dinitrotoluene
Lead	Heptachlor
Mercury	Hexachlorobenzene
Selenium	Hexachlorobutadiene
Silver	Hexachloroethane
Endrin	Methyl Ethyl Ketone
Lindane	Nitrobenzene
Methoxychlor	PCBs
Toxaphene	Pentachlorophenol
2,4-D	Pyridine
2,4,5 TP (Silvex)	Tetrachloroethylene
Benzene	Trichloroethylene
*If pH is the only item on this list that makes the item a mixed waste, it can be neutralized and handled as only Rad Waste.	2,4,5-Trichlorophenol
	2,4,6-Trichlorophenol
	Vinyl Chloride

6. SEALED SOURCES

A sealed source of radioactive material is defined as 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. Sources fabricated by individuals or organizations that are not registered and approved by the Sealed Source and Device Registry maintained by the U.S. Nuclear Regulatory Commission are not considered sealed sources. Radioactive sources, which are not registered and approved, should be treated as unsealed sources and subject to the handling precautions and requirements for open radionuclides.

6.1 General Rules for Safe Use of Sealed Sources

- All sealed sources, regardless of strength, should be clearly labeled or tagged at all times with the activity, isotope, and date of measurement.
- Sealed sources shall be used and handled only in accordance with manufacturer's instructions.
- Sealed sources shall not be modified, destroyed, or otherwise tampered with.
- When not in use, sources shall be secured against unauthorized use or removal.
- Accurate records of sealed source inventories shall be maintained
- Procurement, receipt, and transportation of sealed sources are subject to the same requirements described in sections 4.2, 4.3, and 4.4.

6.2 Leak Testing of Sealed Sources

The Office of Radiation and Nuclear Safety shall ensure that leak tests and physical inventories are performed on those sealed sources specified and at the intervals specified in the applicable radioactive material license conditions or applicable regulations.

Leak testing of sealed sources is performed in accordance with RPP-8, "Leak Testing of Sealed Sources."

6.3 Exemptions for Certain Installed Sealed Sources

An radiation installation consisting only of sealed sources that does not exceed a radiation level of 5 mrem/hour at a distance of 30 centimeters from the surface of the sealed source container or housing, and individual users of such sources, are subject to reduced requirements of posting and labeling (described in Section 11) and radiation safety training (described in Section 10).

7. RADIATION PRODUCING EQUIPMENT

Radiation producing equipment is any equipment that generates ionizing radiation during its operation. Some is equipment uses radiation directly, such as for x-ray imaging, x-ray diffraction or fluorescence analysis. Other equipment generates radiation incident to its primary purpose. Hazardous radiation from an x-ray system may come from the following sources:

- The primary beam
- Leakage or scatter of the primary beam through cracks in defective, or poorly fitted equipment components
- Penetration of the primary beam through the tube housing, shutters or diffraction apparatus
- Secondary scatter emission from the sample or other material exposed to the primary beam
- Diffracted or fluorescence x-rays
- Radiation generated by vacuum tube rectifiers in the high voltage power supply

7.1 Operating Procedures

Normal operating procedures must be written and available to all analytical x-ray equipment users. Written operating procedures must include:

- methods of controlling radiation exposure
- method and frequency of conducting radiation safety surveys
- method of controlling access to the unit
- method of locking/securing the unit both when in use and not in use
- method of alignment
- method and condition for personnel monitoring
- emergency procedures/notification requirements in the event of an accident
- method for maintaining required records
- procedures for inspection and maintenance

X-ray equipment must not be operated differently from that specified in the procedure manual unless written permission has been obtained from the Radiation Safety Officer. The Radiation Safety Officer must also approve deviation from the manufacturer's recommended alignment procedures that are included in the operating procedures.

7.2 Repair and Alignment Procedures

The following safety precautions are to be taken to reduce risks during repair and alignment procedures:

- The main switch, rather than the safety interlocks, must be used to shut down the equipment
- No x-ray tube will be used without a suitable housing to restrict the radiation to a well-defined beam
- A sign stating "Interlocks Not Working" must be posted on the equipment when the interlocks have been defeated for alignment purposes. Prior approval must be obtained from ORNS before defeating safety interlocks
- The beam current (mA) and the beam energy (kV) should be reduced to the lowest possible settings. This will keep the x-ray beam exposures rates low.
- Long-handled tools and extension devices should be used to reduce the risk of the hand entering the beam.

- Radiation monitoring badges should be worn during alignment or maintenance procedures
- Unrestricted areas should be properly posted and temporary barriers set up if the acceptable dose rate in that area is exceeded during repair or maintenance. The area must be under surveillance until normal operations have been restored
- After re-assembly, following alignment or any other repair, or if there is a change in the initial arrangement, the Radiation Safety Officer or the user must check the x-ray equipment for leakage radiation. The results of this survey must be documented in the laboratory records

7.3 Special Considerations for Cabinet-Style X-ray Systems

Commercial x-ray devices that are designed and manufactured to operate with radiation sources fully enclosed and inaccessible to normal users may be subject to reduced requirements for users in terms of training and surveillance. To qualify under this section, the Authorized User must receive written acknowledgement from the Radiation Safety Officer, and the following conditions must be met (older devices may be granted this status without meeting one or more of these conditions only with the approval of the RNSC):

- A key-activated control must be provided to ensure that x-rays will not be generated when the key is removed
- Each door of a cabinet x-ray system must have a minimum of two safety interlocks. Each access panel must have at least one safety interlock
- A control, other than the safety interlock, must be provided to resume x-ray generation following x-ray interruption by a safety interlock
- An easily seen warning light labeled "X-RAY ON" must be present
- Radiation emitted from a cabinet x-ray system must not exceed an exposure rate of 0.5 mrem/hr at any point 5 cm from the external surface at the maximum rated current and voltage. A cabinet x-ray system must contain sufficient shielding and be located so exposure rates in unrestricted areas do not exceed 2 mrem in any one-hour and 100 mrem/yr.

Each such installation must have posted or conspicuously available:

- A current list of approved users of each device, including the date of approval
- Normal Operating Procedures for the device(s)

Personnel dosimetry is not required for cabinet-style x-ray system.

These reduced requirements apply only to the normal operation of the device, and do not apply during alignment, repair, or any other operation where interlocks may be defeated. The Authorized User must be able to restrict use of the equipment during this condition.

7.4 Special Considerations for Electron Microscopes

Electron microscopes (and similar devices such as electron microprobes and ESCA spectrometers) are classified as radiation producing equipment under New York State Department of Health regulations, but carry minimal risk of radiation exposure by reason of design.

No area posting is required for this type of equipment, but the equipment must carry the “Caution – X-ray” or equivalent warning as described in Section 11.

Radiation emitted from electron microscopes, electron microprobes, or ESCA spectrometers, must not exceed an exposure rate of 0.5 mrem/hr at any accessible location on the external surface.

Personnel monitoring is not required for users of electron microscopes.

8. PERSONNEL MONITORING

The documentation of the radiation dose received by persons working with radioactive material and radiation-producing equipment is critical to minimizing such exposures, and ensuring compliance with state and federal regulations. The best available approach to monitoring occupational radiation exposures to individuals is through the use of the *personal dosimeter*. Rensselaer requires appropriate use of dosimeters in a fashion that is minimally intrusive to the worker, yet effective in documentation of compliance with the "As Low as Reasonably Achievable" (ALARA) approach to minimizing radiation exposure. Badges are obtained through the Office of Radiation and Nuclear Safety.

8.1 Monitoring Badges for Users

These devices are obtained by completing a “Request for Personnel Radiation Monitoring Badge Service” and submitting it to the Office of Radiation and Nuclear Safety. The Radiation and Nuclear Safety Committee or the Radiation Safety Officer may impose different requirements than the ones listed below in particular circumstances.

A protected repository in a secure non-radiation area must be used at each installation for storing the personnel monitoring devices when they are not being worn. The Office of Radiation and Nuclear Safety can supply wall-mounted racks for this purpose upon request.

Each individual to whom a badge is issued has the responsibility to ensure its proper wear and use.

8.1.1 Whole Body Monitoring Badges

Whole-body monitoring badges are required for all persons exposed to licensed or registered X-ray, gamma, or high energy (>250 keV) beta radiation sources on a routine basis.

Whole-body monitoring badges that include neutron detection are required for any individuals:

- Working in the LINAC flight stations during operation
- In the RCF when operating
- Handling Plutonium-Beryllium neutron sources

Users of low-energy (<250 keV) beta emitters (e.g. hydrogen-3 [tritium], carbon-14, phosphorus-33, sulfur-35 and calcium-45) do not require whole-body monitoring badges.

Users of installed sealed sources (see section 6.3), cabinet style x-ray systems (section 7.3), or electron microscopes (section 7.4) do not require whole-body monitoring badges.

Whole-body personnel monitoring devices must be worn between the waist and neck and on the front of the trunk of the body.

8.1.2 Extremity Monitoring Badges

Laboratories at Rensselaer that use phosphorus-32 or other energetic (>250 keV) beta emitters are issued finger rings. If there is a reason that a finger ring cannot be used, wrist badges can be issued.

Users of low-energy (<250 keV) beta emitters (e.g. hydrogen-3 [tritium], carbon-14, phosphorus-33, sulfur-35 and calcium-45) do not require extremity monitoring badges.

Extremity monitoring badges should be worn on a finger of the hand in most frequent contact with containers of radioactive material.

8.1.3 Maintenance and Records

Personnel monitoring devices are changed on a quarterly basis or as deemed necessary by the RSO.

Records of personnel exposures shall be maintained by the Office of Radiation and Nuclear Safety.

Yearly radiation exposures shall be supplied to all individuals required to wear dosimetry devices.

The Radiation Safety Officer will investigate any reported exposures that are suspected of not being As Low As Reasonably Achievable (ALARA). In any circumstance, the RSO will begin an ALARA investigation for an exposure in excess of 10% of the applicable limits. The RSO may choose to investigate any exposure that does not conform to expectations based upon proscribed duties or historical trends.

8.2 Monitoring Badges for Visitors

Visitors are any individuals that come to a radiation installation for a short period of time, such as for a demonstration, tour, maintenance, inspection, etc., and who is supervised by an approved user at all times. The requirements for issuing radiation monitoring badges to visitors are the same as listed in Sections 8.1.1 and 8.1.2.

Installations that regularly require radiation monitoring for visitors, such as the LINAC and RCF will be provided with visitor badges at the same time that badges for regular wearers are provided. Other installations that require visitor badges should request them in advance from ORNS.

Reports of exposure are provided to visitors only when reported readings are non-zero (above minimum detectable dose). Those reports are provided along with annual reports for regular users.

A single radiation monitoring badge may be shared by no greater than ten individuals engaged in a tour only. All members of the tour group must remain together and led by an approved user at all times. Each tour participant's information must be recorded on a "Tour Group Exposure Record."

9. REPRODUCTIVE HEALTH

Students, faculty, and staff at Rensselaer may have questions about their working and learning environment before, during, and after a period of pregnancy. More detailed information is available regarding radiation and pregnancy by contacting the Office of Radiation and Nuclear Safety, or regarding other potential hazards from the Department of Environmental Health and Safety.

9.1 Pregnant Users

The New York State Department of Health has regulations concerning fetal dose and dose to the pregnant user. The two most important aspects are that

1. fetal dose regulations apply only to a woman who has voluntarily informed her employer, in writing, of her pregnancy and the estimated date of conception; and
2. the dose to the fetus resulting from occupational exposure of a declared pregnant woman may not exceed 500 mrem for the entire pregnancy and 50 mrem per month after pregnancy is declared.

Any radiation worker who is pregnant or believes that she may be pregnant should contact the Office of Radiation and Nuclear Safety. The Office of Radiation and Nuclear Safety will then take the following steps:

1. Provide an opportunity to submit a Declaration of Pregnancy. For the convenience of the worker, a form entitled "Declaration of Pregnancy" is available in the forms section of the Environmental Health and Safety website. However, any written statement of pregnancy, including estimated date of conception, is a sufficient Declaration of Pregnancy. If a written declaration of pregnancy is not submitted to the Office of Radiation and Nuclear Safety, the worker's dose continues to be controlled under the normal dose limits for radiation workers.
2. Provide information concerning risk of fetal radiation exposure and information on Rensselaer's policies regarding family leave for employees and graduate students.
3. Evaluate the worker's dose history and exposure potential.
4. Make recommendations for reducing radiation exposure.
5. Monitor the worker's radiation dose with regard to worker and fetal dose limits. Any pregnant worker otherwise issued a radiation monitoring badge on a quarterly basis will be issued a badge on a monthly basis for the duration of the declared pregnancy.

9.2 Frequent Questions

Below is a list of pertinent questions that may be asked by a pregnant radiation user.

1. If I become pregnant, am I required to declare my pregnancy?

No. The choice whether to declare your pregnancy is completely voluntary. If you choose to declare your pregnancy, you must do so in writing and a lower radiation dose limit will apply to your embryo/fetus. If you choose not to declare your pregnancy, you and your embryo/fetus will continue to be subject to the same radiation dose limits that apply to other occupational workers.

2. If I declare my pregnancy in writing, what happens?

If you choose to declare your pregnancy in writing, the licensee must take measures to limit the dose to your embryo/fetus to 500 mrem during the entire pregnancy. This is one-tenth of the dose that an occupational worker may receive in a year.

3. Why do the regulations have a lower dose limit for the embryo/fetus of a declared pregnant woman than for a pregnant worker who has not declared?

A lower dose limit for the embryo/fetus of a declared pregnant woman is based on a consideration of greater sensitivity to radiation of the embryo/fetus and the involuntary nature of the exposure. Several scientific advisory groups have recommended that the dose to the embryo/fetus be limited to a fraction of the occupational dose limit.

4. What are the potentially harmful effects of radiation exposure to my embryo/fetus?

The occurrence and severity of health effects caused by ionizing radiation are dependent upon the type and total dose of radiation received, as well as the time period over which the exposure was received. The main concern is embryo/fetal susceptibility to the harmful effects of radiation such as cancer.

5. Are there any risks of genetic defects?

Although radiation injury has been induced experimentally in rodents and insects, and in the experiments was transmitted and became manifest as hereditary disorders in their offspring, radiation has not been observed to cause such effect in humans.

6. Can I tell the Office of Radiation and Nuclear Safety orally rather than in writing that I am pregnant?

No. The regulations require that the declaration must be in writing.

7. If I have not declared my pregnancy in writing, but the licensee suspects that I am pregnant, do the lower dose limits apply?

No. The lower dose limits for pregnant women apply only if you have declared your pregnancy in writing.

8. If I am planning to become pregnant but am not yet pregnant and I inform the licensee of that in writing, do the lower dose limits apply?

No. The requirement for lower limits applies only if you declare in writing that you are already pregnant.

9. How long is the lower dose limit in effect?

The dose to the embryo/fetus must be limited until you withdraw your declaration in writing or you inform the licensee in writing that you are no longer pregnant. If the declaration is not withdrawn, the written declaration may be considered expired one year after submission.

10. If I have declared my pregnancy in writing, can I revoke my declaration of pregnancy even if I am still pregnant?

Yes. The choice is entirely yours. If you revoke your declaration of pregnancy, the lower dose limit for the embryo/fetus no longer applies.

10. RADIATION SAFETY TRAINING

The radiation protection training given by the Office of Radiation and Nuclear Safety is designed to ensure that users of ionizing radiation, both x-rays and radioactive materials, have the knowledge and skill to work efficiently and effectively in an environment with radiation while minimizing radiation exposure to themselves and other workers in the laboratory.

Radiation safety training may be provided through formal classroom training, through electronic presentation using the Traincaster™ system administered by Rensselaer (http://rpi.traincaster.com), or through Rensselaer's Learning Management System (LMS) used with Blackboard (http://rpilms.rpi.edu). All faculty and staff have Traincaster accounts, and all students have access to Blackboard. Others requiring radiation safety training will be provided with appropriate accounts or other means of completing on-line training.

10.1 Training for Individual Users

Radiation safety training for individual users consists of two sections:

1. General training in the proper use and handling of radioactive material and/or other sources of ionizing radiation, and
2. Lab-specific training, covering the particular procedures in which the individual will participate.

All individual users must complete radiation safety training before commencing work with sources of radiation. The content of the initial training may be modified for the specific responsibilities of the individual.

Whether completed in the classroom, through Traincaster, or through Blackboard, records of section 1 of the radiation safety training will be maintained by the Office of Radiation and Nuclear Safety.

Lab-specific training (section 2) is the responsibility of the Authorized User, who should ensure that the individual user has observed can demonstrate the proper procedures for handling the sources of radiation in the lab. This training should be documented and maintained as part of the laboratory records.

Individual users must complete radiation safety refresher training on an annual basis, either through Traincaster, Blackboard, classroom session, or other means established by the Radiation Safety Officer

Users of installed sealed sources (see section 6.3), cabinet style x-ray systems (section 7.3), or electron microscopes (section 7.4) do not require general radiation safety training, but shall complete lab-specific training in accordance with the radiation installation's authorization.

10.2 Training for Ancillary Workers

Ancillary Workers are personnel who may come in contact with or enter an area that contains radioactive material or sources of ionizing radiation incident to their job responsibilities, such as maintenance or cleaning personnel.

Ancillary workers should be trained in identification of radiation warning signs and avoiding radiation hazards. Training can be completed through the Traincaster module entitled "Radiation Safety

Awareness Training" or through a classroom session offered as needed. Ancillary workers do not require annual refresher training.

10.3 Training for Public Safety Personnel

Staff members in the Department of Public Safety are generally considered ancillary workers, with the added responsibility of possibly acting as first responders in an emergency involving sources of radiation. For this reason, a separate training module, "Radiation Safety Awareness for Public Safety Personnel" has been established and should be completed by the appropriate individuals.

11. SIGNS AND LABELS

Radiation warning signs (visible postings on a wall or door) and labels (tagged to individual items) are an important method of identifying potential radiation hazards. Only the proper signs and labels should be used in a radiation installation.

11.1 Notices to Workers

Certain documents must be conspicuously posted in each room, laboratory, or area in which radiation sources are present. All radiation areas must have the State of New York Notice to Employees (Form GEN 301) conspicuously posted. X-ray installations must also have a current copy of the Radiation Producing Equipment Registration Certificate posted. The Office of Radiation and Nuclear Safety will provide these postings.

11.2 Radiation Warning Signs for Rooms and Areas

Radiation warning signs are provided by the Office of Radiation and Nuclear Safety, and should be posted at each entrance to a radiation installation. The signs may be posted on the door to the facility, or on the wall immediately adjacent to the door, but should not be hidden if the door normally remains open when the laboratory is occupied.

Each radiation warning sign will include:

- The standard radiation warning symbol
- Contact information for the Authorized User, the Laboratory Supervisor (if applicable) and the Radiation Safety Officer
- Emergency contact information for the Department of Public Safety
- In areas where radioactive materials are in use, the words “Caution – Radioactive Materials”
- In areas where radiation producing equipment is in use, the words “Caution – Radiation Producing Equipment”

If an area is designated a radiation area or high radiation area (see Glossary), then a separate warning sign bearing the radiation warning symbol and the words “Caution – Radiation Area” or “Warning – High Radiation Area” must be present.

Radiation installations consisting only of installed sealed sources meeting specific conditions (see section 6.3) or electron microscopes or similar equipment (see section 7.4) do not require radiation warning signs to be posted.

11.3 Radiation Warning Labels

11.3.1 Containers of Radioactive Material

Each container in which radioactive materials are used, stored, or transported must be labeled with a “Caution – Radioactive Materials” sign. In the case of storage, the label must also identify the radionuclide, activity, and date of measurement.

If labeling of individual containers (such as small vials or micro-centrifuge tubes) is impractical, the storage rack or container in which they are places may be labeled instead.

Containers used transiently in laboratory work (e.g. beakers, flasks, and test tubes) for a period of a few hours and in the presence of the individual user need not necessarily be labeled. However, all containers must be labeled if left unattended, so it is preferable to label all associated labware before beginning experiments.

Tools or equipment that are segregated and intended only for use with radioactive materials, such as pipette devices, should be labeled with the radiation warning symbol.

11.3.2 Sealed Sources of Radioactive Material

Sealed sources, or equipment containing sealed sources of radioactive material must be labeled with the words "Caution – Radioactive Material." This is required regardless of whether or not the room is exempted from posting under section 11.2.

11.3.3 Radiation Producing Equipment

Radiation producing equipment shall bear a label containing radiation warning symbol and the words "Caution – X-ray," "Caution – Radiation Producing Equipment," or "Caution – This equipment produces radiation when energized." The label should be placed on or as close as practicable to the radiation source.

If the label on the radiation source is not clearly visible from the operating position of the device, an additional label shall be placed there at the position that the equipment becomes energized.

11.4 Removal of Radiation Warning Signs and Labels

Radiation labels must be obliterated or removed from containers and packages when they no longer contain radioactive materials. Labels and markings should be promptly removed from apparatuses which have been checked for contamination and are no longer to be used with radioactive materials. After a final survey of rooms and areas formerly used for radiation work, all signs and labels must be removed.

12. EMERGENCY RESPONSE

A radiological emergency is one which involves either the uncontrolled release of radioactive material or the excessive exposure (exposure in excess of the NYSDOH established guides) of personnel to ionizing radiation. These emergencies will include but not be limited to:

- Personnel exposure or suspected exposure to possible internal deposition of radionuclides. This could be airborne concentrations of radionuclides, body contamination or inadvertent ingestion.
- Personnel exposure (or suspected exposure) to external radiations in excess of established guides.
- Uncontrolled release of radionuclides to the building, premise, neighborhood, or sewers.
- Accidental contamination of onsite areas or equipment.

In an emergency situation, **always contact Public Safety (276-6611) first**. They will be able to contact the Radiation Safety Officer and any others that are need for response.

12.1 Spills of Radioactive Material

12.1.1 Minor Spills

A minor spill is generally considered to be one that consists of less than 100 μCi of a beta or gamma emitting isotope, or 10 μCi of an alpha emitting isotope. However, these thresholds may be reduced by the properties of the material, such as volatility or dispensability. In effect, any spill you are not comfortable handling yourself should be considered a **major spill**.

To respond to the spill:

- Notify other persons in the area of the spill, and not to enter the spill area.
- Wear appropriate lab wear (gloves, etc)
- Use absorbent material to contain radioactive spill
- Use soap and water to clean surfaces
- Dispose of all cleanup material in radioactive waste
- Monitor area with appropriate survey meter and to ensure the radioactivity has been removed
- Notify the Radiation Safety Officer

12.1.2 Major Spill

Response and cleanup of a major spill will be directed by the Radiation Safety Officer. In response to a major spill:

- Notify other persons in the area of the spill.
- Evacuate immediately if spill is of a volatile or dispersible material.
- Immediately remove contaminated shoes or clothing.
- **Contact Public Safety (276-6611)**
- If safe to do so, take any simple measures to reduce the spread of contamination (such as righting containers of radioactive material, etc.)
- Gather affected personnel in nearest accessible safe area to await response from the Radiation Safety Officer.

12.2 Fires Involving Radioisotopes

- Evacuate the area and pull the Fire Alarm on the way out of the building. Proceed to the nearest phone in a safe location and call Public Safety at 6611. Provide Public Safety with a description of the materials involved. Public Safety will notify the Office of Radiation and Nuclear Safety.
- Close any windows and doors that can be reached safely. Do not attempt to fight the fire.

12.3 Accidents or Injuries Involving Radioisotopes

In any emergency, treatment of the injured takes priority over radiation hazards. Do not delay treatment of injured personnel. Ensure emergency response personnel are provided with detailed information.

Always c**ontact Public Safety (276-6611)** to request response to emergency situations. Provide detailed information regarding the emergency.

For serious injuries - call Public Safety (276-6611) immediately to arrange for medical transport.

If anyone accidentally ingests, inhales, or absorbs any quantity of radioactive material, notify the Office of Radiation and Nuclear Safety immediately.

For minor injuries:

- Wash minor wounds thoroughly under water to flush out radioactive material.
- Seek appropriate medical care for the injury.
- Notify the Radiation Safety Officer as soon as it is safe to do so.