RADIATION SAFETY POLICY MANUAL

Prepared and issued under the auspices of

THE RADIATION SAFETY COMMITTEE

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For additional information, contact

THE RADIATION SAFETY OFFICER

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Foreword

Ionizing radiation provides the University community with a powerful tool for medicine and research. The beneficial applications of radiation continue to grow as scientists delve ever further into the workings of our bodies, our environment and our universe. In addition to the benefits derived from the use of radiation, however, there are risks that must be recognized and controlled. The assessment and management of these risks is, itself, a scientific discipline that provides the basis for the contents of this manual.

The responsibility for establishing radiation protection policies and for authorizing the use of specific radiation sources at the University of Utah is delegated to the Radiation Safety Committee. This *Radiation Safety Policy Manual* contains the general policies and procedures adopted by the Committee for the safe use of ionizing radiation in teaching, research and clinical medicine. Additional procedures containing detailed instructions for specific sources or categories of use are available from the Committee through the Radiation Safety Officer. Authorization for the use of any licensed or registered radiation source is conditional upon complete compliance with federal and state regulations, license conditions and with the policies and procedures promulgated by the Radiation Safety Committee.

Although the use of radiation sources is governed by complex regulations and license conditions, the knowledge and performance required of individual radiation users is readily comprehended and accomplished. It is the responsibility of each individual who works with sources of ionizing radiation to know and follow the policies and procedures promulgated by the Radiation Safety Committee and administered by the Radiation Safety Officer.

Raymond F. Gesteland, Ph.D.
Vice President for Research
Distinguished Professor, Genetics

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RADIATION SAFETY POLICY MANUAL

PURPOSE

This manual conveys the official policies of the University of Utah for the control of all sources of, and exposures to, ionizing radiation that are within the jurisdiction of the University. The manual defines responsibilities of individuals and organizations for radiation control, it specifies the policies that guide specific decisions on radiation control matters, and it provides general safety rules and procedures that are obligatory for all users of radiation sources. Additional requirements and procedures not included in this manual are developed, promulgated and enforced as necessary to implement the overall philosophy and policies for radiation protection as presented herein.

Federal and state regulations require a written radiation protection program that includes provisions for keeping doses **as low as reasonably achievable (ALARA)**. All radiation users shall be included in the program and shall be informed of the program and of their individual responsibilities. This manual is intended to satisfy these regulatory requirements.

EMERGENCY PROCEDURES

Radiation Emergency

Any accident, injury or loss of control of a radiation source that could cause an excessive or uncontrolled radiation exposure to any individual is referred to as a radiation emergency. The proper response to any radiation emergency depends upon a thorough understanding of the magnitude of risks, priorities for action and the application of common sense. Each user of radiation sources should be familiar with the basic emergency responses listed below and methods for applying them in his or her own work area. Detailed instructions for coping with radiation emergencies are prepared only for a few special facilities and a few categories of emergency response personnel. The "Emergency Guide" in the front of the Campus Directory provides general instructions on what to do in various kinds of emergency situations.

Responsibilities

The **Public Safety Department** is responsible for overall emergency response communication and coordination. The notification of appropriate response personnel and establishment of necessary communications links during emergencies are services provided by Public Safety.

The **Radiation Safety Officer (RSO)** is responsible for providing technical guidance and assistance on all emergencies involving or potentially involving radioactivity or radiation exposures. The **Radiological Health Department** shall be notified promptly of all accidents or incidents involving radiation sources at the University of Utah. Members of the Radiological Health Department are authorized to act on behalf of the RSO and provide the staff and facilities to deal with radiation emergencies.

RADIATION EMERGENCY NOTIFICATION & ASSISTANCE

Ambulance; Fire Department	**9-911**
University Police	585-2677
Radiological Health Department & **Radiation Safety Officer**	581-6141

(Calls are forwarded to the University Police Dispatcher at night or on weekends)

MEDICAL RADIATION EMERGENCIES

University Hospital Emergency Department	581-2291

(Ask for the Charge Nurse or the Attending Physician and specify **"Medical radiation emergency"**)

Responsible users of radiation sources are responsible for clean up of spilled materials and for assuring that all individuals within their jurisdiction comply with monitoring and reporting requirements established by the RSO.

Facilities or groups with unique radiation emergency response requirements shall maintain and use detailed emergency procedures applicable to their needs.

Protect People!

The first consideration in any emergency is to assist injured persons and to prevent any further injury. For medical assistance, dial 9-911 immediately and report the nature of the illness or injury. If the person may be contaminated with radioactive material, inform the 911 dispatcher of the situation. If you are qualified to render first aid, do so without regard to the presence of radioactivity. **There are no radiation sources at the University that produce radiation exposure risks large enough to prevent giving first aid!** Except for the usual precautions for moving an injured person, individuals should immediately leave the room or area until the extent of the radiological hazard has been evaluated. However, all individuals should remain available in the vicinity until checked for contamination or exposure.

Get Help!

Each individual using radiation sources should know in advance who to call in case of a radiation emergency. If fire, injury or other emergency conditions in addition to radiation are involved, first call the appropriate numbers listed in the front of the Campus Directory. Then call the Radiological Health Department (1-6141) during normal office hours; or call the University Police (5-2677) during off-duty hours.

When reporting any emergency, be sure to state the exact nature of the emergency; then give your name and the phone number from which you are calling, the exact location of the emergency (building, room, nearest entrance, etc.) and the name of the Responsible User, if known. **Do not hang up!** Let the person called end the conversation after all pertinent information is clearly understood.

Contain the Hazard!

Any of the following actions appropriate to the situation should be performed provided they can be carried out safely:

Cover containers of radioactive materials.

Place absorbent material on spilled liquids.

Close the sash on fume hoods, but do not turn off hood exhaust fans.

Close doors to the area and post signs or guards to prevent unauthorized entry.

Allow no one to leave the area without being checked for contamination.

Follow-up Action

If required by the Radiation Safety Officer (RSO), individuals involved in a radiation emergency shall submit specimens for bioassay, surrender personal clothing or other articles for decontamination or assay, and provide pertinent information. Any necessary decontamination or repairs required after a radiation emergency shall be performed only under the direction of the Radiation Safety Officer (RSO).

Re-entry or re-occupancy must be authorized by the RSO. The RSO shall evaluate, record and report, as necessary, any radiation exposures to personnel, loss of radioactive material, or damage to radiation facilities resulting from the emergency.

The Vice President for Research is the official spokesman for the University on matters pertaining to radiation protection. Individuals involved in radiation emergencies should refrain from discussing the event with anyone other than University officials until after a complete evaluation has been made.

BASIS FOR RADIATION PROTECTION POLICIES

Ionizing radiation is capable of producing biological effects that are detrimental to health. It is assumed that any radiation dose, no matter how small, could produce some effect. The purpose of a radiation safety program is to prevent unnecessary radiation exposures, and to control those that are necessary.

Each person who is knowingly exposed to ionizing radiation from sources controlled by the University shall be informed of the risks and of appropriate protection methods, and shall accept personal responsibility for using the available protection.

Radiation-Induced Health Effects

Health effects from exposure to ionizing radiation may be stochastic (random in an exposed population) or deterministic (predictable for an individual).

Deterministic effects may be observed in an exposed individual when a large radiation dose, exceeding a threshold value, is received in a rather short time. A dose smaller than the threshold value will not produce the effect. If threshold dose for a particular effect is exceeded, the effect is almost sure to occur, but the severity of the effect is proportional to the dose.

Stochastic effects are those that occur randomly in an exposed population, usually after a long latent period. Since these effects cannot be distinguished from those that occur in an unexposed population, the cause-and-effect relationship cannot be established on an individual basis, but only on a statistical basis. For these effects it is assumed that there is no threshold dose and that the probability of occurrence is proportional to the dose. However, the severity of the effect, if it occurs, is independent of the dose.

Principles of Radiation Protection

Two basic principles apply to every individual that may be exposed to radiation: **(1)** all radiation doses are to be kept **as low as reasonably achievable (ALARA)**, and **(2)** no dose to an individual shall be allowed to exceed the appropriate **individual dose limit**.

The ALARA principle is applicable even when the potential dose is well below the individual dose limit because it is assumed that some risk may be associated with any dose of radiation, no matter how small. ALARA also means balancing the benefits of dose reduction against social needs and economic considerations.

Dose limits are intended to limit the individual's lifetime risk of stochastic effects from small chronic exposures as well as to prevent non-stochastic effects from large doses.

For individuals who are exposed to ionizing radiation as a direct result of their employment, individual dose limits are based on the philosophy that their total health risks should be no greater than the risks accepted by workers in comparable occupations or industries who are not exposed to radiation.

For anyone who does not receive a direct benefit, e.g. a salary, related to their radiation exposure, the individual dose limits are much smaller than those for radiation users. These "non-occupational" limits are based on comparisons with the ordinary risks of living, rather than on risks due to employment.

Radiation Dose - Quantity and Units

Radiation dose limits are specified as a quantity called the **effective dose equivalent** in units of **rems**. *The effective dose equivalent is the dose to the whole body from penetrating x rays that would impart the same lifetime risk of detrimental health effects as the sum of the actual doses to all tissues and organs of the body from all types of ionizing radiation.* (See the Glossary for a more detailed, technical discussion of this quantity and the included adjustment factors.) The University expresses all doses and limits in millirems (1 mrem = 0.001 rem). Throughout the rest of this Manual, unless otherwise clearly specified, "dose" means "effective dose equivalent".

Radiation Doses and Risks

The doses and related health risks produced by non-occupational radiation exposures may be helpful for understanding the risks from occupational doses. In the U.S., the annual average dose from cosmic rays and other natural sources is 100 mrem, the effective dose from radon in homes is 200 mrem, medical examinations contribute an average of 53 mrem and consumer products and other manmade sources deliver another 9 mrem, for a total of approximately 360 mrem per year. In Utah, because of increased cosmic radiation and greater concentrations of radioactive minerals in the ground, the **average annual dose is more than 400 mrem**.

The risk of fatal cancer from all causes, averaged over the entire U.S. population, is approximately 1 in 4, or 25%. It is recognized, however, that certain sub-groups, e.g. smokers or residents of large cities, have cancer risks that are above average, while other groups have risks that are below the average. For most stochastic effects, a given dose of radiation is believed to increase the baseline risk for a population group by a constant fraction or proportion.

A continuous dose rate of 400 mrem per year for 70 years is estimated to contribute approximately 1.5% to the baseline risk of fatal cancer. The majority of radiation users receive occupational doses of much less than 400 mrem per year. An additional dose of 400 mrem per year for 20 years would increase the baseline risk for fatal cancer by 0.3%.

Individual Dose Limits

The primary occupational dose limit is 5,000 millirems per year, effective dose equivalent.

The dose limit for members of the general public, including all persons who are not classified as radiation users, is 100 millirems per year. No person shall be classified as a radiation user simply to justify a higher dose limit.

The embryo-fetus may be more susceptible to radiation effects than an adult and is, therefore, subject to a lower dose limit. **The dose limit for the embryo-fetus is 500 millirems during the entire gestation period**. As a further precaution, it is advisable to keep the monthly doses below 50 millirems. This degree of protection for the embryo-fetus can only be achieved with the cooperation of the employee, who should notify her supervisor as soon as the pregnancy is known. The limit is enforceable only if the pregnant employee gives written notice to her supervisor, who shall also notify the RSO.

ALARA Policy

The University is committed to an effective radiation protection program to eliminate unnecessary exposures to radiation and to reduce all exposures to levels that are **as low as reasonably achievable (ALARA)**, taking into account all social and economic considerations. The **ALARA** principle is a formal requirement of the U.S. Nuclear Regulatory Commission and the Utah Department of Environmental Quality.

The ALARA principle is implemented by a comprehensive radiation protection program that includes specific requirements and procedures for:

1. training of all radiation users,
2. safety evaluations of proposed facilities or projects utilizing radiation in any way,
3. regular surveys of work areas for contamination and exposure rates,
4. monitoring of radiation exposures to groups and individuals,
5. investigations of all exposures that exceed predetermined levels, and
6. audits of the program by the Radiation Safety Committee and/or other qualified experts.

Each facility or program utilizing radiation machines or radioactive materials shall be justified on its merits and shall be specifically authorized by the Radiation Safety Committee. The review and evaluation by the Committee covers the training and experience of individuals authorized to use radiation sources, the adequacy of facilities and equipment, and procedures for the safe use of radiation sources.

Specific rules and procedures may be issued by the Radiation Safety Officer (RSO) in support of the **ALARA** concept as well as to assure compliance with all legal and regulatory requirements. The RSO and supporting staff provide training, consultation and other services to radiation users to assist them in controlling radiation sources and reducing exposures.

RESPONSIBILITIES

The possession and use of radioactive materials and other sources of ionizing radiation are governed by regulations of several federal and state agencies, and by conditions of specific licenses issued to the University. The Board of Regents delegates authority to the President of the University who appoints and empowers the organizations and individuals described below to develop, maintain and administer an effective program for radiation protection.

The University permits the use of ionizing radiation sources for beneficial applications in teaching, research, medicine and community service when such sources are acquired and used in accordance with the policies, principles and rules contained in this manual. The protection of the health and welfare of each member of the faculty, staff, student body and general public is of primary importance; however, the financial, legal and societal obligations of the University are also considered in the implementation of practical radiation protection practices.

Rules and procedures promulgated for use within the University shall comply with the regulations and requirements of the federal and state agencies that license and regulate radiation sources and uses.

Technical assessments, evaluations and interpretations shall also be consistent with the guidance and recommendations of authoritative advisory bodies, such as the International Commission on Radiological Protection, the National Council on Radiation Protection and Measurements, and the American National Standards Institute.

Radiation Safety Officer (RSO)

The Radiation Safety Officer (RSO) is the individual specifically appointed by the University, and named on the radioactive materials licenses, to establish and enforce such procedures as are necessary to assure compliance with applicable regulations and license conditions, and to ensure effective implementation of the policies and rules established by the Radiation Safety Committee. **Depending on the context, "RSO" may also refer to any individual specifically designated to act on behalf of, and under the supervision of, the RSO.**

The RSO is authorized and directed to promulgate and enforce such procedures as are necessary to assure compliance with applicable federal and state regulations and to ensure the accurate interpretation and effective implementation of the policies and rules established by the Radiation Safety Committee. The RSO is authorized to terminate immediately any project or operation that presents a radiological threat to health or property.

Actions to restrict the acquisition of radioisotopes or the use of any radiation source, for the purpose of enforcing compliance with radiation protection regulations or procedures shall be initiated only by the RSO. The affected user may appeal the action to the Radiation Safety Committee or to the Vice President for Research.

The RSO shall establish radiation exposure investigation levels and, if those levels are exceeded, initiate a prompt investigation of the cause of the exposure and a consideration of actions that might be taken to reduce the probability of recurrence.

The RSO is responsible for:

1 maintaining copies of pertinent regulations, license applications, licenses and amendments;

2 maintaining all records of the acquisition, use and disposition of radiation sources within the jurisdiction of the University;

3 maintaining records of radiation monitoring and surveillance related to exposures of individuals from University controlled sources; and

4 providing instruction and services to radiation users for the safe and authorized use of radiation.

With respect to the use of radioactive materials, the RSO is responsible for investigating spills, losses, thefts, unauthorized receipts, uses, transfers, disposals, misadministrations, and other deviations from approved radiation safety practice and implementing corrective actions as necessary.

The RSO reports to the Vice President for Research on administrative matters and to the Radiation Safety Committee on technical matters. The RSO receives direction from the RSC with regard to policy and provides technical advice to the Committee, radiation users and the administration. At least annually, the RSO shall brief management on the radiation protection program.

Radiation Safety Committee (RSC)

The Radiation Safety Committee (RSC) is the governing body for all aspects of radiation protection within the University, including all affiliated research, clinical, instructional and service units utilizing radiation sources in facilities owned or controlled by the University. The RSC will ensure that all possession, use and disposition of radiation sources by University personnel complies with pertinent federal and state regulations and with the specific conditions of licenses issued to the University, and that all concomitant radiation exposures are maintained ALARA.

The RSC is composed of individuals who represent the various uses of radiation within the University and are knowledgeable and experienced in the safe use of radiation sources, as well as individuals representing various administrative and service functions. Representatives of the nursing service and of University management are required on the Committee. The RSO is an *ex officio* member of the Committee. The Committee is required to meet at least once during each calendar quarter.

The RSC is empowered and directed to promulgate policies, rules and procedures for the safe use of radiation sources. The RSC is responsible for assuring that only qualified individuals are permitted to use radiation sources, or to supervise such use by others. The RSC oversees, reviews and audits the activities of the Radiation Safety Officer (RSO) and supporting staff, and all users of University radiation sources. The RSC reports to the Vice President for Research. The RSC may, at its discretion, establish subcommittees to perform specific functions on behalf of the entire committee.

The RSC reviews recommendations for maintaining individual and collective doses ALARA. On the basis of safety, and with regard to training and experience, the RSC shall approve or disapprove any individual who is to be designated as the RSO, or who is to be authorized as a responsible user.

Each application for use of any source of ionizing radiation is first reviewed by the Radiation Safety Officer (RSO) to assure that it is complete. If the application is for possession of a generally licensed category of radioactive material, it may be approved by the RSO without review by the RSC. All other applications shall be submitted to the User Authorization Subcommittee of the RSC for evaluation and approval. If the subcom-mittee does not vote unanimously for approval, the application shall be referred to the main committee (RSC) for resolution. The RSO shall notify the applicant promptly of the action taken by the RSC.

Amendments to existing authorizations are normally approved by the RSO if, in the judgement of the RSO, the amended use is within the intent of the initial authorization. If the requested amendment is for a completely different category of use, i.e. if it requires substantially different training, experience or facilities than those required for the initially approved use, the request shall be referred to the RSC.

On the basis of safety, and with the advice and consent of the RSO and the management representative, the Committee shall review and approve or disapprove changes in radiation safety procedures that do not conflict with any regulatory requirement or license condition and that will not decrease the existing level of protection or safety.

At each quarterly meeting, with the assistance of the RSO, the Committee shall review a summary of occupational radiation doses. The Committee is required to review the overall radiation safety program at least annually.

A written procedure, available from the chairperson or from the Radiation Safety Officer, specifies the membership, responsibilities, authority and operating rules of the RSC.

Radioactive Drug Research Committee and Human Use Subcommittee (RDRC-HUS)

In accordance with Food and Drug Administration (FDA) regulations, the Radioactive Drug Research Committee (RDRC) is empowered and required to evaluate and to approve or disapprove all research and developmental uses of radioisotopes on or in humans. The RDRC also serves as the Human Use Subcommittee of the Radiation Safety Committee (HUS). As required by Utah Division of Radiation Control, the HUS evaluates and approves or disproves all proposed uses of ionizing radiation sources on or in humans for investigational or non-routine clinical procedures. Review of an application for the use of ionizing radiation sources on or in human subjects is conducted by the RDRC and/or the HUS only after the adequacy of the facilities and qualifications of the investigator have been verified by the Radiation Safety Officer.

The RDRC is composed of five or more individuals professionally qualified in the use of radiation in medicine and clinical research, including a nuclear medicine physician, a nuclear pharmacist and an individual with special competence in radiation safety and radiation dosimetry. The Chairperson of the RSC and the Radiation Safety Officer are *ex-officio* members. The RDRC meets at least quarterly to review and act on applications for use of radiation sources in or on human subjects. The RDRC reports to the RSC in writing at least once each calendar quarter.

Nuclear Reactor Safety Committee

The Reactor Safety Committee is composed of at least five individuals who are knowledgeable in fields that relate to nuclear reactor safety. The Reactor Supervisor and the RSO are *ex officio* members of the Committee. Members of the nuclear reactor operating staff shall not constitute a majority of the Committee members.

The Reactor Safety Committee is required to meet at least once during each calendar quarter. The responsibilities and operating rules of the Committee are specified in the Technical Specifications of the Reactor Facility License (No. R-126) issued to the University by the U. S. Nuclear Regulatory Commission.

Radiation Users

A **"radiation user"** is any individual whose official duties or authorized activities include handling, operating, or working in the presence of, any type of radiation source, whether or not such use is confined to a restricted area.

A **"normally exposed" radiation user** is an individual who could receive more than one-tenth (10%) of any occupational radiation dose limit.

A "potentially exposed" radiation user is an individual who is unlikely to receive one-tenth (10%) of any occupational dose limit, but who works with sources that could produce a significant dose accidentally.

A **"minimally exposed" radiation user** is an individual who is unlikely to receive one-tenth (10%) of any occupational radiation dose limit. This category includes individuals who routinely handle only small quantities of radioactive materials, and others exposed only intermittently, e.g. most nurses, emergency and security personnel, maintenance, receiving, custodial and housekeeping personnel.

Each user must understand and follow the general rules and procedures for working safely with radiation sources as presented in this manual. Each radiation user shall participate in radiation safety training as specified by the RSO.

As a condition of employment, each radiation user is required to provide certain personal information to the RSO. The required information includes (1) primary identification data, e.g. full name, birth date, sex, and University identification number (social security number); (2) previous training and experience with radiation sources; and (3) current employment status, including job title or description, department, supervisor, and work location.

Personal records of radiation users also contain the scores obtained on tests taken to demonstrate knowledge of radiation safety procedures, data obtained from monitoring of external and internal radiation exposures, and reports on any injuries or abnormal incidents related to the use of radiation sources. Individual radiation user records are treated as confidential and are available only to those with a legitimate need for the information. An individual may review the contents of his or her personal radiation user file at any time, and may obtain a summary of his or her radiation history annually, or upon termination of employment, upon written request to the RSO.

Any radiation user may communicate directly, in confidence and without prejudice, with the RSO or any member of the Radiological Health Department, the Utah Division of Radiation Control or the U.S. Nuclear Regulatory Commission on any matter concerning radiation protection.

Qualified User

A **"qualified user"** is an individual who through appropriate training and experience is qualified and authorized to work independently with radiation sources and to supervise such use by others.

Responsible User

A **"responsible user"** is a "qualified user" authorized by the Radiation Safety Committee to acquire and use specific radiation sources, and to supervise such use by others. Authorization for the use of any radiation source is conditional upon complete compliance with regulations, license conditions and the procedures promulgated by the University's Radiation Safety Committee. Because of the responsibilities and liabilities involved, a responsible user shall be an employee of the University, and is normally a principal investigator and/or faculty member who has primary scientific, financial and legal responsibility for a research program or clinical application, and signature authority on at least one University account.

Each proposed use of radioactive materials, x-ray or other radiation generating machines must be submitted to the Committee, via the Radiation Safety Officer (RSO), for review before implementation. Specific forms and data to be submitted are prescribed in the attachments to this procedure. The descriptions of facilities and equipment, the training and experience of the user, and the operating or handling procedures shall be provided in sufficient detail to permit the Committee to evaluate the safety of the proposed use.

To assure that all records related to radiation sources, users and conditions of use are accurate and up-to-date, the RSO may require that parts or all of the application be verified or resubmitted periodically. If the updated information includes changes that are significant to safety, the application will be submitted to the Committee for re-authorization.

An individual is approved as a responsible user only after:

1 demonstrating to the satisfaction of the RSO and the RSC that he or she has had sufficient training and experience in the safe use of radiation sources and is in

a position to exercise physical and financial control of the intended radiation sources;

2 providing to the RSC a detailed plan for the proposed radiation use, including secure storage, safe handling, control of exposures and appropriate waste disposal methods and updating such information by means of periodic revisions or renewals of the authorization request as required by the Committee;

3 acknowledging and accepting in writing the responsibility for:

a instruction in radiation protection practices for all personnel working with radiation sources and/or within facilities for which he or she is responsible;

b acquisition of equipment, supplies and services necessary for the safe use of radiation sources;

c security against misuse or theft of radiation sources;

d maintaining reasonably accurate inventory records for all radionuclides, including acquisitions, uses, transfers, disposals and decay;

e performing regular bioassays, exposure and/or contamination surveys, and maintaining related records as appropriate to the nature of the radiation use and as specified by the RSO;

f notification of the RSO of any accident, injury or abnormal incident related to radiation sources; and

g arranging for authorization of another individual to assume the preceding responsibilities, or to suspend or terminate all radiation uses, prior to any extended absence.

The responsible user may use the authorized radiation sources personally or, with the approval of the Radiation Safety Committee, may delegate the operational responsibilities to a qualified user. Each responsible user shares a responsibility with all other responsible users to serve on the Radiation Safety Committee, if needed to provide the necessary diversity of expertise.

Radiological Health Department

The Radiological Health Department provides the administrative and technical services in support of the radiation protection program. The Director of the Department is the RSO and reports to the Vice President for Research.

ACQUISITION OF RADIATION SOURCES

Radioactive Materials

Radioactive materials may be used for any legitimate educational, clinical or research purpose. However, they may be purchased, or otherwise obtained, only by individuals specifically authorized by the Radiation Safety Committee. **The use of radioactive materials is conditional upon compliance with specific procedures established by the Committee**.

Each application for use of any source of ionizing radiation is first reviewed by the Radiation Safety Officer (RSO) to assure that it is complete. If the application is for possession of a generally licensed category of radioactive material, it may be approved by the RSO without review by the RSC. All other applications shall be submitted to the User Authorization Subcommittee of the RSC for evaluation and approval. If the subcommittee does not vote unanimously for approval, the application shall be referred to the main committee (RSC) for resolution. The RSO shall notify the applicant promptly of the action taken by the RSC.

Amendments to existing authorizations are normally approved by the RSO if, in the judgement of the RSO, the amended use is within the intent of the initial authorization. If the requested amendment is for a completely different category of use, i.e. if it requires substantially different training, experience or facilities than those required for the initially approved use, the request shall be referred to the RSC.

Each user of radioactive materials shall maintain a complete record of all acquisitions, uses, transfers and disposals of such materials and provide these data to the RSO in a timely manner. The receipt of any radioactive material, regardless of the manner in which it is obtained, must be reported promptly to the RSO on a form provided for that purpose. **Before any radioactive materials may be transferred to another responsible user, or to another organization, authorization must be obtained from the RSO.**

Analytical X-ray Machines

All operable x-ray generating machines used in University of Utah facilities shall be authorized by the Radiation Safety Committee and shall be registered with the Utah Division of Radiation Control. All authorizations and registrations (including fees) shall be submitted to the Radiation Safety Officer (RSO) for review and processing. The RSO shall also be notified before moving, transferring or disposing of any x-ray machine.

The responsible user for each analytical x-ray machine shall assure that detailed operating procedures are available and that each operator has received appropriate training and understands and follows the correct procedures.

Self-shielded Irradiators

The acquisition, installation and use of large gamma-ray irradiators involves long-term commitments of University resources, space and administrative controls. In addition to concerns of safety and security, the issues of long-term custody and ultimate disposal costs must be carefully considered by individuals and departments acquiring an irradiator and by the Radiation Safety Committee (RSC).

The complete description of the irradiator and its intended location shall be included with the "RADIATION MACHINE USE APPLICATION" (RPR 2C). The application shall be approved by the RSC before submittal to the licensing agency. No commitment to purchase an irradiator shall be made until the license application has been approved by the RSC.

Particle Accelerators

All operable research accelerators used in University of Utah facilities shall be authorized by the Radiation Safety Committee and shall be registered with the Utah Division of Radiation Control. All authorizations and registrations (including fees) shall be submitted to the Radiation Safety Officer (RSO) for review and processing. The RSO shall also be notified before moving, transferring or disposing of any particle accelerator.

The responsible user for each accelerator shall ensure that detailed operating procedures are available and that each operator has received appropriate training and understands and follows the correct procedures.

RADIATION SAFETY TRAINING

Regulations governing the possession and use of radioactive materials and other radiation sources require that every individual working with or in the presence of such sources be instructed in the applicable provisions of regulations and license conditions, in the potential health problems associated with exposure to radiation, in the precautions and procedures required for safe use of radiation, and in the proper use of protective and measurement devices. The extent of the training is to be commensurate with the potential risk of radiation exposure to the individual.

The primary responsibility for providing adequate training for individuals who work routinely with radiation sources rests with the responsible user. For individuals who are only occasionally exposed to radiation, e.g. most nurses, housekeeping, maintenance, security and delivery personnel, the responsibility for training lies with their supervisors. Generally, the responsible user or supervisor will fulfill this responsibility by assuring that each person attends the appropriate training program offered by the Radiation Safety Officer (RSO). The supervisor or responsible user may also provide the training and submit a statement to the RSO listing the individuals trained and the content of the training.

"Normally exposed" and "potentially exposed" radiation users are required to have more extensive training than are "minimally exposed" users. Because of the ongoing experience acquired by individuals working regularly with radiation sources, retraining is not always required. Periodic retraining may be required: (1) if regulations, license conditions or procedures change, (2) if contamination or exposure problems occur, or (3) if procedures are not being followed. Records of training for "normally" and "potentially exposed" radiation users are kept individually with their dosimetry records.

Since many "minimally exposed" users are only infrequently or intermittently exposed, and may not benefit from regular experience with radiation protection, retraining on a regular schedule is generally required. Records of training attendance for these users are maintained on a group basis, since most "minimally exposed" users do not have individual dosimetry records.

The RSO is responsible for developing, conducting and documenting appropriate training on radiation protection

for all categories of radiation users. For each category, the RSO shall establish an appropriate frequency and minimal requirements for the content of the training program. The RSO shall maintain appropriate records of training offered and completed to assure compliance with regulatory requirements.

CONTROL AND MONITORING OF EXPOSURES TO EXTERNAL RADIATION SOURCES

Sources that emit penetrating radiations (gamma and x rays, energetic beta particles, neutrons, etc.) can cause radiation exposures from outside the body. These external exposures shall be controlled by appropriate shielding and by limiting the time spent in close proximity to the source.

Safety Evaluations

X-ray machines, particle accelerators and other fixed radiation sources shall be surveyed at least annually to verify adequacy of shielding, alarms, interlocks, and other safety-related apparatus or equipment. During the safety survey, the potential exposure rates to operators are evaluated to assure that they are ALARA and that operators are monitored appropriately.

Medical X-ray Units

Personnel who are required to attend patients undergoing various radiological procedures are to be protected from radiation exposure to the greatest extent feasible, consistent with providing safe, competent care of the patient.

During medical x-ray procedures, patients should be immobilized without being held, if at all possible. Never allow any part of the body of anyone but the patient to be in the primary x-ray beam.

During medical fluoroscopic procedures, the primary source of exposure to attending personnel is radiation scattered from the patient. Since radiation intensity decreases rapidly with distance from the source, it is advisable to step back from the patient whenever possible.

Even a little shielding is very effective against the low-energy radiation scattered from the patient. If you must stay near the patient, wear a lead apron.

Radioactive Materials

Radionuclide sources that emit penetrating radiations should be stored and handled within appropriate shielding whenever physically possible. For gamma and x rays, high-density materials, e.g. lead, provide the most effective shielding. For energetic beta-particle emitters, e.g. P-32, low-atomic-number materials, e.g. plastics, should be used as the primary shielding to minimize bremsstrahlung production. Radioactive materials should be stored in designated containers and locations when not in actual use.

The intensity of radiation exposure decreases rapidly with distance from the source. Radionuclide sources that emit penetrating radiations should be stored away from regular work areas; they should be handled, when necessary, with tongs or forceps to eliminate direct contact and to increase the distance from the source.

Exposure Evaluation and Monitoring

External exposures are readily detectable with portable instruments and personal monitoring devices (dosimeters). Radioisotope work and storage areas should be surveyed for external exposure rates whenever changes are made in the quantities, locations or shielding of radiation sources. The results of such surveys shall be provided to all individuals working in the area to help them to control their own exposures.

Potential radiation exposures from any source, or within any facility, are evaluated by the RSO to determine protection and monitoring requirements. In most cases, exposures are evaluated for groups of individuals engaged in similar activities and exposed to comparable sources. In other situations, monitoring of individual exposures may be necessary.

Personal Dosimeters (Badges)

A radiation dosimeter does not provide protection; it merely verifies, after the fact, the adequacy of the radiation control program. Also, radiation dosimetry data are not, of themselves, appropriate to determine risk to any individual; however, they can sometimes help an individual to develop safe work habits.

The primary purposes for performing individual monitoring are:

1 to monitor the individual's radiation environment and to evaluate the adequacy of the radiation control program,

2 to promote safe radiation working habits by individuals,

3 to document radiation accidents,

4 to satisfy medical and legal requirements as are necessary to protect the employee and the employer, and

5 to comply with pertinent federal, state and local regulations.

Anyone who will use radiation sources shall complete the "RADIATION USER PERSONAL DATA" form (RPR 1). Based on the location and nature of the anticipated radiation use, the RSO shall determine if an individual dosimeter is needed; if so, it will be issued in about two weeks.

Radiation users who are "minimally exposed" to penetrating radiation from external sources, i.e. those who are unlikely to receive more than one-tenth (10%) of any external occupational dose limit, are not required to wear personal dosimeters.

All radiation users who are "normally exposed" or "potentially exposed" to external sources of penetrating radiation are required to wear one or more personal dosimeters. Users subject to general whole-body exposures are issued "body badges", which are to be worn on the front of the torso at all times while working with radiation sources, or on the collar if a lead-impregnated apron is worn. Individuals who routinely wear lead-impregnated aprons may be issued a second badge to be worn on the front of the abdomen under the apron. The purpose of the second badge is to provide additional information for estimating the effective dose equivalent; for females, it also monitors the potential dose to the embryo-fetus in the event of pregnancy.

Extremity dosimeters (ring badges) are required when significant quantities of radioisotopes that emit penetrating radiations must be routinely handled directly, or when the hands or fingers could be exposed accidentally to a high intensity source such as an x-ray diffraction unit. Rings badges are available in small, medium and large sizes; if a ring doesn't fit, please request a different size! The ring badge shall be worn inside a glove with the label facing the radiation source, i.e. toward the palm of the hand with the highest potential exposure. Check the badge for contamination as part of each routine survey for personal contamination.

Individuals who have been issued one or more dosimeters for any reason are required to wear them at all times when they are working in the presence of
any radiation source. When not being worn, dosimeters shall be stored away from heat and radiation sources but they should not be taken home or worn away from work.

All dosimeters shall be returned promptly at the end of the monitoring period. Dosimeters not returned by the 5th of the month after they were worn, but within the next 30 days, are considered to be late. Dosimeters returned more than 30 days late, or damaged or misused in any way that invalidates the reading, are considered to be lost.

Investigation Levels

The RSO shall establish investigation levels, i.e. levels of radiation dose received during a monitoring period, for each category of "normally exposed" radiation users. Whenever the dose recorded by a dosimeter exceeds the investigation level, the RSO shall cause an investigation to be made to determine the cause of the dose and steps that might be taken to prevent recurrence.

CONTROL AND MONITORING OF INTAKE OF RADIOISOTOPES

It is the responsibility of each radiation user to be thoroughly familiar with the University's ***Radiation Safety Policy Manual*** and the Radiation Procedures and Records (RPR's) applicable to his or her work, to follow safe work practices, to be aware of actual or potential radiation exposures, and to keep all exposures to levels that are as low as reasonably achievable (ALARA). Each person who handles unsealed or dispersible radioisotopes is responsible for the control and containment of radioactivity and for performing regular surveys of personnel, personal effects, equipment and work areas using methods that will assure the detection of contamination before significant exposures occur.

The responsible user must assure that the necessary monitoring is performed, recorded and reported. Routine evaluations of all radioisotope laboratories, including surveys for contamination, are also performed by the RSO.

In research facilities, application of the ALARA principle dictates that no removable contamination shall be tolerated indefinitely. Whenever contamination is detected, it shall be removed promptly to prevent its spread and the possible exposure of other individuals. Refer to "CONTAMINATION LIMITS AND ACTION LEVELS" (RPR 10B) for specific limits and required responses.

Each person who works with potentially dispersible radioactive materials is responsible for:

1 knowing the basic properties of the radioactive materials used, e.g. the half-lives of the nuclides, the types of radiation emitted, the annual limit on intake (ALI), and any shielding that may be required;

2 being aware of actual or potential radiation exposures and keeping all exposures to levels that are as low as reasonably achievable (ALARA);

3 following safe work practices and the instructions or procedures provided by the responsible user and the RSO;

4 the control and containment of radioactivity and for performing regular surveys of personnel, personal effects, equipment and work areas using methods that will assure the detection of contamination before significant exposures occur;

5 providing and/or analyzing urine samples, obtaining thyroid counts, or wearing personal dosimeters as specified by the RSO; and

6 recording the results of all radiation surveys and screening bioassays promptly, completely and accurately.

The responsible user shall ensure that the necessary monitoring is performed, recorded and reported. Routine evaluations of all radioisotope laboratories, including surveys for contamination, are also performed by the RSO.

Handling Precautions

Ingestion of radioactivity shall be prevented by avoiding mouth contact with any items handled in a radioisotope laboratory (pipettes, pencils, etc.), by prohibiting eating, drinking and smoking in radioisotope handling areas and by careful attention to personal hygiene. Appropriate protective apparel, including lab coats, gloves and closed-toe shoes, shall be worn whenever potentially dispersible radioisotopes are being used to prevent contamination of skin and personal clothing. Lab coats and gloves that have been worn in radioisotope handling areas shall not be worn to public area such as the cafeteria, library, etc.

Contamination Surveys

Surveys for contamination on the hands and clothing shall be performed immediately after working with significant quantities of radioisotopes to assure detection and removal before any radioactive material enters the body. Any radioactive material on the skin shall be removed promptly by normal washing. If it cannot be removed easily, the RSO should be contacted to assist with decontamination. Follow the instructions in "RADIOISOTOPE LABORATORY SAFETY PROCEDURES" (RPR 11) for performing and reporting contamination surveys.

Airborne Activity

The risk of inhalation of radioactive materials is greatly reduced by performing all operations that release or generate gases, vapors or dusts in approved fume hoods. Emergency response personnel may be required to wear filtered or supplied-air respirators to prevent inhalation of contaminants. Whenever the probability of airborne contamination is significant, the RSO should be notified and air sampling may be required.

Bioassays

Although the emphasis of radiation protection is on prevention of exposures, measurement and evaluation of exposures is also necessary. Bioassay is the determination of the kind and amount, and sometimes the location, of radioactive material in the human body by direct measurement *in vivo* or by analysis *in vitro* of materials excreted or removed from the body. Bioassay is an important tool for evaluating actual or suspected internal contamination with radioactive materials.

Monitoring and dose assessment is required for any individual who is likely to an intake in one year of one-tenth (10%) of the annual limit on intake (ALI) of all nuclides combined. To assure that this requirement is met in all cases, individual intakes of smaller quantities shall be detected and evaluated. The procedure for "BIOASSAYS FOR INTERNAL RADIOACTIVITY" (RPR 12) specifies conditions, frequencies and methods for performing bioassays to assure that an annual intake of 0.1 ALI, whether as a single intake or as chronic or multi-

ple intakes, is not only detected, but determined quantitatively.

Individuals who handle dispersible radioiodine compounds may be required to obtain *in vivo* measurements by the RSO of radioiodine in the thyroid. Individuals who handle other radioisotopes in dispersible form may be required to perform assays of radioactivity in urine on a routine basis to verify the absence of radioactivity in the body or to determine the magnitude of any exposure. Other types of assays may be utilized if, in the judgement of the RSO, such assays will meet the intent of this policy more effectively.

A bioassay is required whenever personal contamination or injury caused by a contaminated object occurs, or if airborne radioactivity may have been inhaled. Routine bioassays, at intervals specified for the nuclides used, are required from each user who handles more than minimal quantities of potentially dispersible radionuclides. A routine bioassay may be waived by the RSO when appropriate surveys for contamination, conducted during and after each use of radioactive material according to recommended procedures, demonstrate that there was essentially no exposure to unconfined, dispersible radioactive material.

Thyroid Protection

Regular contamination surveys and thyroid monitoring have proven to be effective in preventing unnecessary exposures to radioiodine. Routine thyroid measurements are capable of detecting approximately 10 nCi in the thyroid and verification measurements are required at thyroid burdens of 20-70 nCi, depending on the time since the last measurement.

Potassium iodide (KI) is effective for blocking the uptake of radioiodine by the thyroid if taken at about the same time, or shortly before, the intake. However, KI is not totally risk free and shall not be used for routine protection. The risk of a serious adverse reaction from a dose of KI is approximately the same as the health risk from a small intake of radioiodine that would be detected by routine thyroid counting.

Users should rely on careful handling techniques to prevent unnecessary exposures to radioiodine. Under the normal conditions of contamination control and monitoring required in radioisotope laboratories, the risk of radiation exposure is not sufficient to justify any additional risk from KI ingestion.

PERSONAL EXPOSURE INVESTIGATIONS AND REPORTING

The University is committed to maintaining all radiation doses to levels that are as low as reasonably achievable (ALARA). One method for accomplishing the ALARA goal is to investigate situations and incidents that lead to unusual exposures, even if no regulatory limit is exceeded. To assure that unexpected radiation exposures are evaluated, investigation levels are established well below the dose limits. Investigations are conducted and reported in accordance with "PERSONAL EXPOSURE INVESTIGATIONS AND REPORTING" (RPR 46).

For external exposures, the investigation level (IL) is based on the expected (normal) exposure for a category or specific group of radiation users. Values of the IL for doses to the body or to the extremities for various groups are listed in the table on the following page.

For internal exposures, the IL is 0.05 ALI per single intake or per calendar quarter. Annual intakes exceeding 0.1 ALI for all nuclides combined shall be included in the calculation of total effective dose equivalent for purposes of determining compliance with annual dose limits and reporting requirements.

Potential intakes due to personal contamination or injury involving radioactive materials shall be investigated regardless of the actual radiation dose.

Any radiation dose to an individual that exceeds the annual dose limit shall be investigated and reported to the regulatory agency. If the dose is received as the result of a single event, it shall be reported either immediately or within 24 hours, depending on the magnitude of the dose. The RSO directs the investigation, evaluates the results and submits the report to the regulatory agency. The exposed individual shall provide information regarding the circumstances of the exposure. The responsible user shall be informed of the exposure and of any subsequent restrictions that may need to be imposed on the individual.

REIMBURSEMENTS AND FEES

Routine radiation protection services are provided by the University to all radiation users. However, services that are not routine and that involve extraordinary costs are charged to the user incurring the costs. Optional services,

not recommended or required for radiation protection, but provided upon request, will also be charged to the requesting user. Charges for non-routine and optional services are administrative decisions to be made by the Director of Radiological Health in consultation with the Vice President for Research and, if appropriate, with the affected radiation user(s).

Incentive fees, or fines, are imposed on users who fail to meet certain obligations related to their use of radiation sources. These charges are comparable to parking citations and library overdue book fines; they are not intended to generate revenue, but to improve compliance with radiation protection requirements. Incentive fees are reviewed and approved by the Radiation Safety Committee.

Extraordinary Costs

Any major cost item incurred unexpectedly by a single radiation user may fall into this category. One example would be the disposal of mixed wastes or exceptionally large volumes or activities of radioactive wastes involving special handling or disposal surcharges. Another example would be a fine levied against the University as a result of gross negligence or willful violation of procedures by a user. The method of reimbursement will depend upon the circumstances.

Optional Services

Any supplies or services that are not recommended or required for radiation protection, or that are normally the responsibility of the user but are provided by the Radiological Health Department as a convenience to the user, will be billed to the user at cost plus handling expenses. One example of an optional service is furnishing personal dosimeters to individuals who do not require personal monitoring under the criteria contained in this manual. Protective clothing, equipment, instrument repairs, etc., are other examples of services or supplies that may be provided for the convenience of users.

Incentive Fees or Fines

Procrastination or negligence on the part of radiation users may result in violations of regulations or license conditions and/or additional expense to the University. To encourage radiation users to fulfill their obligations in an appropriate and timely manner, fees are assessed for failure to comply with certain requirements. If the failure to comply is due to circumstances beyond the control of the individual, this should be discussed immediately to avoid the assessment of a fee.

Late and lost fees are billed on a Campus Order to the Responsible User who shall enter the account number to be charged. **The account shall not be a restricted fund, e.g. a 5-#####**. The Responsible User is expected to obtain reimbursement to the account from the personal funds of the individual responsible for the late or lost fee.

A late fee will be charged for each personal dosimeter returned after the specified exchange period for the month of use but before the exchange period for the following month. After that time, a lost fee will be charged. A lost fee will also be charged for a personal dosimeter reading that is lost or invalidated because of physical damage to or loss of the dosimeter, contamination of the dosimeter with radioactivity, exposure of the dosimeter to radiation sources while it is not being worn as directed on the person to whom it was issued, etc.

A late fee will be charged for each bioassay result or sample not submitted to the RSO within the interval scheduled for completion of the assay. If an individual will not be available for the bioassay within the scheduled interval, the late fee may be avoided by prompt notice to the RSO and a request to reschedule the bioassay.

Incentive fees are intended to be large enough to be significant to the individual and to achieve the intended compliance with monitoring requirements. The fees authorized by the Radiation Safety Committee for each occurrence are:

Personal dosimeters returned late by no more than one month but resulting in a valid reading: **$10.00**

Personal dosimeter readings returned more than one month late, lost or invalidated due to damage, contamination, improper exposure, etc.: **$15.00**

Bioassay results or samples not submitted within the scheduled interval: **$10.00**

LABORATORY EVALUATIONS, SURVEYS AND AUDITS

The RSO shall ensure that all areas where radioactive materials are stored or handled are inspected at appropriate

intervals to ascertain the radiological risks and to evaluate the control measures in use. Radiation surveys shall be performed, when necessary, by technically qualified personnel using instruments appropriate to the nature of the radioactive materials to be detected or radiation exposures to be measured.

For radioisotope laboratories, i.e. those where dispersible radioisotopes are used, the frequency of routine evaluations is based on the "interval inventory", as defined in the Radiation Safety Policy Manual. The "interval inventory" is the total quantity of radioisotopes introduced into the laboratory in a month, averaged over the most restrictive bioassay interval, expressed in ALIs. The routine evaluation frequencies for various average monthly inventories are shown in the box below.

If no work with radioisotopes is being done, and all radioisotopes are stored in a locked location conspicuously labeled with a sign that requires notification of the RSO prior to any further use of radioisotopes, the laboratory may be considered to be inactive. An inactive laboratory need not be surveyed routinely, but the status shall be verified at least annually.

The nominal survey frequencies given in the box are to be interpreted as guidelines. In cases where continuing contamination problems are found, the interval between surveys will be shortened. If survey results obtained over a period of a year indicate no contamination or exposure problems, the routine survey interval may be increased. In no case, however, will the interval be more than double the nominal interval. To assure a realistic and independent evaluation of typical conditions, the schedule for surveys may be varied randomly.

SEALED SOURCE LEAK TESTS

Sealed sources of radioactive material shall be tested for leakage at regular intervals to verify the integrity of the source containment and, in the unlikely event of failure, to detect the escape of radioactive material before serious contamination of facilities, equipment or personnel occurs. The frequency of leak tests, and the sensitivity of detection of escaping radioactivity, shall comply with the regulations or license conditions specified by the agency authorizing the possession of the source. Leak tests shall be performed only by qualified individuals using procedures approved by the Radiation Safety Officer. Records of sealed source leak tests shall be maintained by the Radiological Health Department.

CALIBRATION OF INSTRUMENTS

All portable radiation survey instruments used for measuring exposure rates or determining the quantities of radioactivity present in samples or on surfaces (as contamination) are to be calibrated **at least once a year**. Calibrations are to be performed by individuals who meet the specified qualifications and using sources and procedures that assure compliance with federal and state regulations and license conditions, i.e. "CALIBRATION AND USE OF PORTABLE SURVEY INSTRUMENTS" (RPR 52).

Instruments for measuring exposure rates are calibrated for linearity of response on all useful ranges. Instruments used for contamination surveys are calibrated for detection efficiencies for various nuclides, as well as for linearity of response.

Instruments that are used for making quantitative in vitro or in vivo measurements of radioactivity for determination of radiation doses, concentrations of radioactivity in effluents, or for verification of other aspects of regulatory compliance, shall be calibrated at regular intervals, as appropriate for the particular instrument. Operating instructions, either supplied by the manufacturer or prepared by the user, shall be maintained in a manner that would allow a competent individual to use the equipment properly, even on an irregular basis.

Dose calibrators shall be checked for linearity, geometrical variation and accuracy at the time of installation. Linearity tests shall be performed quarterly. The accuracy and precision of each dose calibrator shall be checked daily with NBS-traceable standards, e.g. Co-57, Ba-133 and Cs-137. The daily readings shall be recorded on a log sheet; if not within 5% of the comparable readings obtained previously, the instrument shall be adjusted, recalibrated or removed from service for repair. All appropriate tests shall be repeated following repair or adjustment of a Calibrator, depending upon the nature of the adjustment or repair.

TRANSPORTATION AND SHIPMENT OF RADIOACTIVE MATERIALS

Radioactive materials of any kind, transported on public roads on or off University property by other than University personnel using University vehicles, shall be packaged and labeled in compliance with U.S. Department of Transportation (DOT) regulations. Radioactive materials may be shipped from the University to another organization or individual only after verification by the Radiation Safety Officer that all transfer, packaging, labeling and transportation requirements have been met.

The DOT Office of Chief Counsel has determined that "hazardous materials transported by a state agency which are packaged and handled solely by state employees and transported in state owned and operated vehicles are not considered to be in commerce and are therefore excepted from the Hazardous Materials Transportation Act and the Hazardous Materials Regulations developed under the Act." (Letter to Keith J. Schiager from DOT dated 19 February 1993). However, all transportation of radioactive materials, including that performed by University employees using University vehicles, shall be conducted safely and in accordance with approved University procedures, i.e. RPR 55.

To assure that all requirements for shipment are met, and that appropriate records are maintained, a written authorization form and one or more check lists shall be prepared by the individual responsible for the shipment and approved by the RSO before the shipment is made. The instructions and forms for various applications are contained in Radiation Procedures and Records related to those applications.

RADIOACTIVE WASTE MANAGEMENT

All users of radioactive materials shall be instructed in the requirements for segregation and labeling of radioactive wastes. They shall also be encouraged to prevent the unnecessary generation of all radioactive wastes, particularly mixed waste, and to minimize the quantities of those wastes that are unavoidable.

Radioactive waste materials must be properly segregated, packaged and labeled by the user prior to collection for disposal. For the safety of all personnel involved in radioactive waste disposal, users must take all reasonable precautions to deactivate, detoxify and neutralize hazardous waste materials. All radioactive waste materials must be prepared and labeled properly before they will be picked up for disposal; wastes found to be improperly prepared or labeled may be returned to the user for reprocessing or repackaging under the supervision of the RSO.

Radioactive wastes (radwastes) shall be collected, stored, packaged, shipped and disposed of in accordance with all pertinent state and federal regulations. The RSO shall prepare and maintain procedures for handling radwastes that will ensure the protection of the employees involved in such duties and keep all radiation exposures ALARA. Specifications for segregation and packaging of radwastes shall be based on specific regulations or regulatory guidance, and include a record-keeping system that will allow complete tracking and accounting for all radwastes shipped to a disposal site or disposed of locally.

Special attention shall be directed to the minimization of mixed wastes and solid wastes containing long-lived radionuclides. Mixed wastes are hazardous wastes, as defined by the U. S. Environmental Protection Agency, that also contain radioactivity. For radwaste management purposes, any nuclide with a half-life of more than 100 days is considered "long-lived." The responsibilities of radiation users for radwaste management are specified in "RADIOISOTOPE ACQUISITION AND DISPOSITION" (RPR 13).

Radioactive wastes (radwastes) shall be collected, stored, packaged, shipped and disposed of in accordance with all pertinent state and federal regulations. The RSO shall prepare and maintain procedures for handling radwastes that will ensure the protection of the employees involved in such duties and keep all radiation exposures ALARA. The RSO shall also maintain records that allow complete tracking and accounting for all radwastes shipped to a disposal site or disposed of locally. Specifications for segregation, packaging and disposing of radwastes are contained in "RADIOACTIVE WASTE MANAGEMENT" (RPR 54).

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GLOSSARY

ACRONYMS AND ABBREVIATIONS

ALARA: The basic premise of radiation protection, i.e. that all radiation doses should be kept **As Low As Reasonably Achievable**, taking into account social and economic considerations, through the application of sound radiation protection practices, procedures and engineering controls.

ALI: The **Annual Limit on Intake** is the quantity of any radionuclide which, if taken into the body, produces an effective dose to internal organs that is equivalent in risk to the annual whole body dose limit of 5 rems. Because of differences in physiological transport mechanisms, the ALIs vary depending on the route of intake. For purposes of contamination control and bioassay procedures, the ALI for ingestion is used, since that is the most common route of accidental intake in research laboratories.

RSO: The **Radiation Safety Officer (RSO)** is the individual specifically appointed by the University, and named on the radioactive materials licenses, to establish and enforce such procedures as are necessary to assure compliance with applicable regulations and license conditions, and to ensure effective implementation of the policies and rules established by the Radiation Safety Committee. Depending on the context, **"RSO" may also refer to any individual designated to act on behalf of the RSO**.

QUANTITIES AND UNITS

Activity: A quantity of a radionuclide specified by the mean rate of spontaneous nuclear transformations which it undergoes. The common unit of activity is the **curie (Ci),** defined as the quantity of radioactivity which decays at the rate of 37 billion transformations per second.

Quantities of radioactivity of biological or environmental interest are commonly expressed in sub-multiples of the curie:

1 millicurie (mCi) = 3.7×10^7 s^{-1}

1 microcurie (μCi) = 3.7×10^4 s^{-1}

= 2.2×10^6 min^{-1} (dpm)

1 nanocurie (nCi) = 37 s^{-1} = 2,220 dpm

1 picocurie (pCi) = 0.037 s^{-1} = 2.22 dpm

The new international standard unit for activity is the **becquerel (Bq)**
1 Bq = 1 transformation per second.

Dose: Dose, as used in this manual, may refer either to absorbed dose or to dose equivalent, depending upon the context and the units used.

Absorbed dose is the mean energy per unit mass imparted to any matter by ionizing radiation. The common unit of absorbed dose is the **rad**, defined as an absorbed energy of 100 ergs per gram of material. The new international standard unit is the **gray (Gy)**, defined as an absorbed energy of 1 joule per kilogram of material; 1 Gy = 100 rads.

Dose equivalent refers to the biologically effective dose, defined as the product of absorbed dose and a quality factor dependent upon the type of ionizing radiation. The common unit of dose equivalent is the **rem,** defined as the absorbed dose in rads multiplied by the quality factor. The new international standard unit for dose equivalent is the **sievert (Sv),** defined as the absorbed dose in grays multiplied by the quality factor; 1 Sv = 100 rems. Regulatory dose limits are expressed in rems to permit equivalent biological doses from different kinds of radiation to be combined.

Exposure: "Exposure" usually refers to any condition which creates the potential for any individual to receive a radiation dose, either from external irradiation or from internal contamination with radioactive materials.

For radiation measurements, "exposure" refers to the intensity of x or gamma irradiation, specified by the ionization produced in air. The common unit of exposure is the **roentgen (R)**. An exposure of 1 R delivers almost 1 rad (0.869 rad in air or 0.93 rad in soft body tissues). Submultiples of the roentgen are normally combined with time units to express exposure rates, e.g., milliroentgens per hour (mR/hr), etc.

GLOSSARY

SOURCES

Radiation Source: Any "Radiation Machine" or "Radioactive Material" emitting or capable of producing ionizing radiation.

Radiation Machine: Any device capable of producing ionizing radiation except those which produce radiation only from radioactive material.

Radioactive Material: Any solid, liquid or gaseous substance which spontaneously emits any type of ionizing radiation.

Radioisotope: As used in this manual and related procedures, a "radioisotope" is any radioactive nuclide used in unsealed or dispersible form. This terminology is used primarily to characterize the form of the material and the nature of the use.

Reference Quantity: A quantity of any radioisotope related to its relative hazard potential and used to prescribe requirements for handling, monitoring, labeling and disposal.

Interval Inventory: The total quantity of radioisotopes introduced into the lab each month, averaged over the bioassay interval, expressed in ALIs.

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 which are likely to be encountered in normal use and handling.

AREAS

University Facility: Any real property owned by or under the control of the University, whether permanently or temporarily.

Radioisotope Laboratory: Any room or area in which 10 or more Reference Quantities of unsealed radioactive materials are stored or used.

Controlled Area: Any area to which access is limited for any reason. X-ray rooms are controlled administratively by the personnel who operate the x-ray equipment. Radioisotope laboratories are controlled by posting and locking for the purpose of preventing unauthorized removal of radioactive materials. Exposure to radioactive materials is prevented by controlling the materials, not by limiting normal access to the laboratory when it is open and attended.

Restricted Area: Any area to which access is limited for the purpose of protecting individuals against undue risks from exposure to radiation and/or radioactive material. The mere presence of any radiation source, if adequately controlled to limit potential exposures, does not necessitate a restricted area designation. Areas containing sources with the potential for producing significant exposures require specific authorizations and procedures or posting for access control and are designated as restricted areas.

Radiation Area: Any accessible area in which an individual could receive a dose equivalent exceeding 5 mrem in 1 hour at 30 cm (1 ft) from the source or from any surface the radiation penetrates.

High Radiation Area: Any accessible area in which an individual could receive a dose equivalent exceeding 100 mrem in 1 hour at 30 cm (1 ft) from the source or from any surface the radiation penetrates.

USERS

Radiation User: Any individual whose official duties or authorized activities include handling, operating, or working in the presence of any type of radiation source is classified as a radiation user. For purposes of evaluating radiation protection requirements, radiation users may be considered as belonging to one of the following groups:

Normally exposed users are those who may be expected to receive doses exceeding 10% of the occupational limits. Radiation doses to these individuals are individually monitored.

Potentially exposed users are those who are unlikely to receive a dose greater than 10% of any occupational limit, but who work with sources that could produce large accidental doses, e.g. accelerators or therapy units. Radiation doses to these users are individually monitored.

Minimally exposed users are those who are unlikely to receive any radiation dose greater than 10% of any occupational limit. This category includes individuals who do not work routinely with radiation sources, but whose official duties may occasionally bring them into areas where radiation exposures may occur, e.g. most nurses, emergency, security, maintenance, receiving and shipping personnel, custodial and housekeeping staff. Radiation training and monitoring for these users are conducted and recorded on a group, rather than an individual, basis.

Qualified User: An individual who through appropriate training and experience is qualified and authorized to work independently with radiation sources and to supervise such use by others.

Responsible User: An individual authorized by the Radiation Safety Committee to acquire and use specific radiation sources, and to supervise their use by others, in compliance with pertinent regulations and under conditions approved by the Committee. Responsible users shall demonstrate, to the satisfaction of the Committee, competence in the safe use of radiation sources by virtue of appropriate training and experience. Responsible users shall be in a position to assume full responsibility for all radiation sources under their control.

MONITORING AND SURVEYING

Contamination Survey: A systematic investigation to determine the presence, or to verify the absence, of radioactive materials in unwanted locations, e.g. on the body or personal clothing, on surfaces of objects that may be touched or handled, on equipment or materials to be removed from a restricted area, etc.

Wipe Test: The detection and evaluation of removable contamination by measurement of radioactive material wiped from the surface onto an absorbent material such as a filter paper.

Exposure Survey: A systematic investigation to determine external radiation exposure rates at specific locations where individuals may be present and potentially exposed.

Penetrating Radiation: Ionizing radiation from external sources capable of delivering significant doses to organs or tissues more than 1 cm deep in the body, e.g. x or gamma rays and neutrons.

Nonpenetrating Radiation: Ionizing radiation from external sources that is not likely to deliver significant doses to organs or tissues more than 1 cm deep in the body, e.g. beta particles and low-energy photons.

Bioassay Interval: The bioassay interval for a particular radioisotope is the maximum time that may elapse between bioassays that will assure detection of the verification level for a given assay method. The bioassay interval for a particular radioisotope is determined by its physical and metabolic characteristics, and by the instrumentation used for the measurement. See BIOASSAYS FOR INTERNAL RADIO-ACTIVITY (RPR 12).