University of Missouri - St. Louis

HANDBOOK OF OPERATIONS
INVOLVING THE USE OF RADIATION SOURCES

This Handbook is part of the University of Missouri - St. Louis
License to possess and use Radioactive Materials

August 2002

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FOREWORD

August 2002

This Handbook of Operations is the official guide in all matters relating to radiation protection and control in the operations of the University of Missouri at St. Louis. This institution has applied for or received an Academic, Research and Development License of Limited Scope from the U. S. Nuclear Regulatory Commission (NRC) for possession and use of specified byproduct materials. This handbook is an integral part of the license granted by the NRC. The authority to enforce compliance with the license issued to the St. Louis campus is delegated by the President of the University of Missouri to the Chancellor who may further delegate specific aspects of compliance enforcement.

These rules and regulations are part of the total responsibility of the campus to conform to the terms and conditions of the license. It is incumbent, therefore, upon each person licensed or authorized to use a radiation source covered by the license to become familiar with and to observe the rules and regulations contained herein. A copy of the license and other documents related to it are maintained in the campus Environmental Safety and Health where they may be examined. The terms campus and university used in this handbook refer only to the St. Louis campus.

In its negotiations with the Nuclear Regulatory Commission to obtain amendments to extend and enlarge the provisions of its license, the university makes specific statements about how it proposes to safeguard the material to be used. The NRC license reviewer may request additional information to be supplied before a license amendment can be issued. The University must protect itself by limiting its promises to those necessary and reasonable to accomplish the proposed use. If the Commission will not accept what is submitted, the university must consider whether or not more should be offered, because to do more will cost more and the proposed use may not be worth the extra expense. By this give-and-take exchange, a definition of a "satisfactory level" of radiation control emerges for the issue at hand.

The State of Missouri's Radiation Protection Regulations pertain to all sources of ionizing radiation **not** covered by the Federal regulations. Since the Federal regulations for safe use of radioactive materials cover only byproduct, source, and special nuclear material, the State regulations are intended to control operation of x-ray machines, naturally occurring radioactive materials, and accelerator produced radioactive materials. Because the university regulations have been prepared to cover other such radiation sources, no change in the intent of this handbook is required. However, to comply with the State regulations, the university must relate to the Missouri Department of Health in the same way it relates to the NRC.

To perform the tasks necessary to implement the program of radiation protection and control, the St. Louis campus, under license agreement with the NRC, has chosen to enter into contracts for Health Physics (Radiation Safety) services and has delegated to the Manager of Environmental Health and Safety the responsibility of coordination of the program on a day-to-day basis. The responsibilities of the consultant Radiation Safety Officer (RSO) and his or her staff are described in Section 1.4.

Regulations adapted from the Federal and State codes, interpreted according to the needs of the campus, are provided in this handbook. Section 1 addresses the overall management of the Radiation Safety program. Section 2 provides the guidelines for safe use of radiation sources in research and development applications common to a university; Section 3 provides the outline of the inspections to be performed by Health Physics staff members; and Section 4 provides the instructions for disposal of radioactive wastes.

For faculty and staff who may be submitting an application for use of radiation sources for the first time, attention is directed to Section 5. That section contains the necessary instructions for completing the application forms and details the procedure by which the application is approved. Any questions not adequately covered by the text should be directed to the Environmental Health and Safety office, Telecommunity Building - Police, telephone 516-5155, or to the Office of the Vice Chancellor for Administrative Services, 516-6100.

Because the conditions of use will change with time, it is expected that the rules and regulations will change correspondingly. For this reason, the handbook has been bound in looseleaf form with pagination to facilitate changing single sections. The section heading date is for reference.

MANAGEMENT OF RADIATION SAFETY

1.1 GENERAL

Responsibility for management of the University of Missouri is vested in the Board of Curators. Executive responsibility and authority for administration of operations within the University, consistent with the policy set by the Board, are delegated to the President. The President, in turn, delegates to the Chancellors the responsibility and the authority for execution of operations conducted on each of the campuses. The organizational chart on page 1-4 shows the interrelationships of the elements of the radiation safety program for the St. Louis campus.

Based on this document, the Radiation Safety Officer (RSO) develops and maintains procedures necessary to establish uniform practice throughout the campus for the use of radioactive materials and other hazardous sources of radiation. Coordination and surveillance of procedural, monitoring, and control functions by the Radiation Safety Officer are established to insure that sources of radiation are being procured, used, and disposed in a safe manner. Mechanisms established to provide this oversight are outlined herein.

The Chancellor is responsible for providing adequate support for the campus health physics operations. The Chancellor may delegate this responsibility to the head of an operating division which has related interests or capabilities. Whenever this support cannot be provided adequately, the program of use of radiation sources will be curtailed. The RSO will continuously evaluate the campus program and report the findings periodically to the Chancellor or Chancellor's designee.

1.2 RESPONSIBILITIES OF THE RADIATION SAFETY OFFICER

The Radiation Safety Officer oversees and participates in the control of radiation hazards arising from utilization of radiation sources as designated in the license. In this capacity the RSO:

- Implements the policies of the campus,
- Reviews all uses of sources to insure compatibility with appropriate license conditions,
- Provides liaison to the NRC in negotiations for licenses on behalf of the Chancellor,
- Develops and maintains uniform methods, standards, and procedures for appropriate health physics coverage,
- Provides consultation on radiation safety issues to investigators, to Institutional Safety staff, and to others having a need for such information,
- Provides staff assistance to the administration of the campus as required,
- Designs, duplicates, and maintains a supply of all standard forms for health physics use,
- Writes and publishes all general guidelines or procedures for radiation safety,
- Provides an audit of the Radiation Safety program for the Chancellor or Chancellor's designee,
- Performs investigations of health physics related activities on the campus. In the event of persistent failure by an authorized user under the license to satisfy the performance standards established, the consultant RSO shall inform the Institutional Safety Office of the situation, and report the results of any investigations to the person designated by the Chancellor;
- Provides the follow-up necessary to insure, when necessary, that appropriate corrective action has been taken, and reports to the Chancellor or designee the status of any pending corrective action.

If an emergency condition occurs, the Radiation Safety Officer shall be notified immediately by the user, department involved, or Institutional Safety designee and the RSO shall respond as follows:

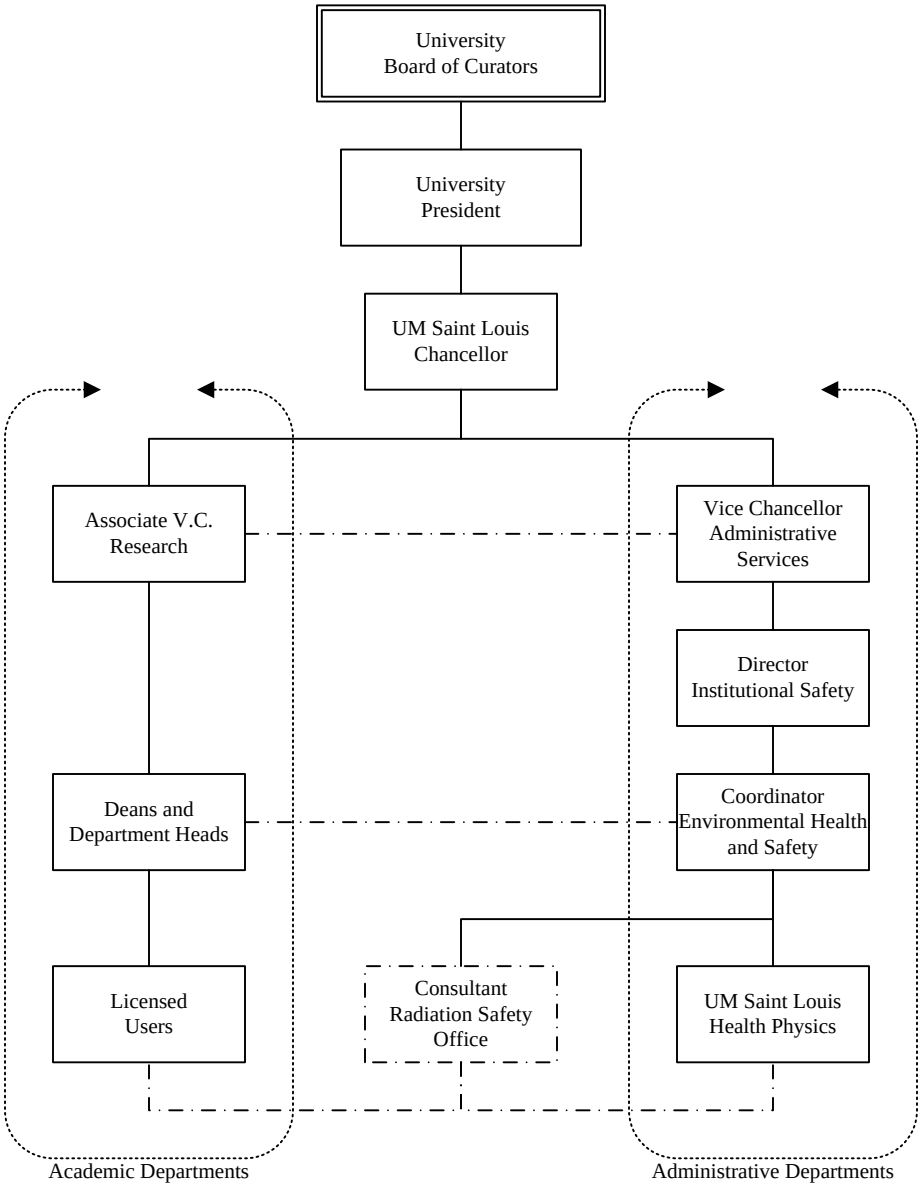
- Determine if appropriate initial action has been taken, and if not, go to the site of the emergency and initiate such action.
- If deemed necessary, take direct action to safeguard personnel and facilities. Such action includes the prompt shutdown of a radiation-producing device, a laboratory in which radioactive materials are used, or a facility in which radiation sources are present. The RSO will then report to the Institutional Safety designee, or other appropriate campus administrator, to state the reasons for the extraordinary action.
- Report to the NRC incidents arising from licensed activities as required by the Federal regulations.
- Provide appropriate follow-up to ensure that license conditions continue to be met.

1.3 RESPONSIBILITIES OF THE HEALTH PHYSICS OFFICE

Administration and support of the Radiation Safety program is the ultimate responsibility of the Chancellor. Responsibilities for program implementation are delegated through Administrative Services to the Director of Institutional Safety, who further directs the Health Physics staff in the Environmental Health and Safety (EHS) office. Through this organizational structure, the Radiation Safety program provides for the following:

- Compliance with all conditions of the license.
- Regular inspections of the laboratory facilities of each investigator licensed and authorized to use radiation sources.
- Evaluation of applications for use of radiation sources to assure that the campus can provide adequate support and meet anticipated license requirements.
- Control procurement of radioactive material as required by University Procedures
- Develop, operate, and maintain a facility suitable for the storage of radioactive wastes for decay to background or preparatory to disposal by a licensed contractor.
- With the assistance of the licensed users maintain releases to levels as low as is reasonably achievable.
- Assist users in the development of special procedures as necessary or requested.

1.4 MANAGEMENT STRUCTURE FOR RADIATION SAFETY



2. RADIATION CONTROL

August 2002

2.1 GENERAL

The University of Missouri - St. Louis has a diversified program of research utilizing radioactive materials and other sources of radiation. This diversification complicates the assessment of exposure possibilities necessary to provide adequate control of the hazards arising from these uses. It is not that a single laboratory constitutes a serious control problem, but a number of such laboratories, each using different materials and different experimental techniques, collectively become a substantial concern. The instructions of this section are intended to aid the investigators in the application of radiation sources without compromising the health and safety of the users or anyone else. While the the EHS Manager and RSO will assist the licensed user in maintaining safe conditions, primary responsibility remains with the user.

This Section contains guidelines which are intended to minimize the exposure of individuals to radiation or radioactive contamination associated with the operations of the campus and to protect the welfare of the community-at-large. Federal and State regulations governing the use of radiation sources are intended to accomplish the same objectives; consequently, as long as the recommendations in this Section are followed, the university will remain in compliance with the regulations. Since guidelines made to cover general situations cannot always cover special situations, there will be instances in which they do not apply or in which a satisfactory interpretation cannot be made. At such times, the RSO should be contacted for assistance, and if the issues cannot be resolved, it will be presented progressively to those named in the above Flowchart.

Recommended methods for protection from radiation and for control of contamination by radioactive materials are outlined in NCRP Report No. 30. Methods recommended for radiation protection from x-ray machines are outlined in NCRP Reports No. 33, No. 35, No. 36 and No. 49. Hazards to personnel involved in the handling of radiation sources arise from the following kinds of exposure:

* Internal exposure resulting from deposition of radioactive materials within the body by way of ingestion, inhalation, entrance through breaks in the skin, or penetration of the skin barrier or

* External exposure of the whole body or parts of the body arising from penetrating radiations such as x and gamma rays, high-energy beta particles, and neutrons.

Hazards to personnel using x-ray equipment can be minimized or eliminated effectively by use of properly designed radiation shields, safety interlocks, and appropriate techniques. With intensities many orders of magnitude greater than that from most gamma-emitting sources, the potential of an injury produced by exposure from an x-ray machine is significantly greater. On a relative basis, therefore, very careful use of x-ray equipment is indicated. There is the advantage, however, that an x-ray machine can be turned off when not in use.

The relative hazards of the different radioactive materials in common use, expressed in terms of the quantity of each that presents a low, medium, high, or very high hazard are illustrated in NCRP

Report No. 30. This reference chart is used by the RSO in the review of applications to use radioisotopes and the guidance of users or potential users of radioactive materials. Users should be familiar with the relative hazard of each material and should apply safeguards, accordingly.

The referenced chart does not provide for adjustment of the relative hazard due to the form of the material nor for the type of operation being performed. Values given on the chart may be modified according to the following scale:

OPERATIONAL FACTORS

Type of Operation	Multiply Maximum Activity (mCi) Values by
Storage	100
Very simple wet operations	10
Standard chemical operations	1
Complex wet operations with risk of spills	0.1
Simple dry operations	0.1
Dry and dusty operations **or** those where isotopes are evolved as gases	0.01

These values apply essentially to open bench operations for chemical or physical forms that are not modified by contact with air. For example, tritium in the form of water vapor is more hazardous than tritium released as a gas. On the other hand, these values do not account for the reduction in hazard afforded by containment in fume hoods or glove boxes.

Some studies have indicated an increase in toxicity of about a factor of ten for tritium when it is bound in an organic form that remains stable within the body and is not eliminated by metabolic processes.

A chemical form that increases the stability of the compound will decrease the risk of inhalation and transport by absorption through the skin, which reduces somewhat the problem of containment.

A listing of the publications which have served as a basis for the recommendations to follow and which may be of additional assistance to the users of radiation sources is maintained by the RSO.

2.2. PERSONNEL RADIATION CONTROL

Persons working with or handling sources of radiation may control external exposure to themselves by utilizing time, distance, and shielding factors. The exposure from a point source emitting gamma radiation varies: a) directly with the time of exposure, b) inversely with the square of the distance to the source, and c) inversely with the absorption thickness for radiation of the shielding material. It is a generally accepted practice for radiation safety that work with radioactive materials requires the experimenter to be as far from the source as possible to accomplish the operation without physical strain and in a minimum of time. At a suitable distance, the necessary further reduction in exposure rate is accomplished by adding shielding between the source and the experimenter.

The radiation safety program is dedicated to the principle of maintaining individual exposures at levels as low as reasonably achievable (ALARA). This must be a cooperative effort in which each individual exercises responsible judgment in the use of potentially hazardous material. It is the function of the EHS Manager and RSO to assist the investigator to accomplish the goal of minimizing exposures.

2.2.1 General Rules of Safe Laboratory Practice

The control of an internal exposure caused by the entry of radioactive material into the body requires proper use of equipment, good housekeeping, and good personal habits. Some rules for experimenters using these materials are the following:

* Materials authorized for use shall always be under the secure control of the authorized user or secured in an identified radioactive material use or storage area.

* All items (e.g., GM survey meters) necessary for the safe conduct of the experiment should be checked to ensure their availability and operational status before an experiment is started.

* Smoking is not permitted inside campus buildings, and food and drink are not allowed in laboratories.

* Refrigerators shall not be used for common storage of food and radioactive materials.

* Gloves should be worn at all times when handling radioactive materials. If there is a break in the skin below the wrist, they must be worn.

* The laboratory should be kept neat and clean. Equipment or material not being used should be stored in a place away from the work area.

* Pipetting by mouth is prohibited. Rubber bulbs, syringes, or other mechanical devices shall be used.

* Radioactive material in liquid form should be stored and transported in double containers. Place all containers in designated acrylic boxes or on a lipped tray during use.

* All transfers and dilutions shall be performed in functioning exhaust hoods or glove boxes, unless it is completely safe to do otherwise (see Section 2.3.1).

* Work should be planned ahead, and whenever possible, a simulation or dry run should be accomplished to test the procedure.

* All items of equipment intended to provide features of safety shall be evaluated periodically to insure that they are providing the safety intended. A fume hood in which radioactive materials are handled shall provide a reasonably uniform air flow through the opening of the hood of at least 100 linear feet per minute with the sash half open (working height).

* Flammable liquids, such as ether, benzene, and acetone, shall not be permitted in the laboratory where radioactive materials are used or stored unless such flammables are contained in U.L. approved safety cans with anti-flashback screens and are used in a properly vented enclosure.

* Pressure bottles or compressed gas tanks shall not be used or stored in the laboratory where radioactive materials are used or stored unless they are securely mounted to a wall or bench or other rigid system.

2.2.2 Protective Apparel

Protective apparel includes laboratory coats or coveralls, gloves, shoe covers, safety glasses, and respirators. In most cases,

however, a laboratory coat and gloves should provide adequate protection from contamination. The laboratory coats intended for use while working with radioactive materials are to be used with the following conditions:

* They should be buttoned up when worn.

* They should not be worn out of the laboratory area.

* They **shall not** be stored with street clothes.

* They **shall** be monitored every day of use and prior to being laundered.

2.2.3 Personnel Monitoring

In accordance with the requirements of Federal and State regulations, all persons likely to be exposed to significant quantities of radiation shall wear one or more personal monitoring devices dosimeters) during working hours. These dosimeters will be changed and processed at regular time intervals. A record of the dose received during the interval and quarterly and total accumulations will be

maintained by the RSO or EHS Manager. Requests for monitoring service should be addressed to the EHS Manager. The campus presently uses personal monitors of the following types:

> Body and area badges that are sensitive to beta, gamma and x radiation. The badge consists of a covered thermoluminescent dosimeter (TLD) with two filters enclosed in a plastic holder. These filters adjoin the TLD on either side so that the front and back filters are of the same density and thickness and are in the same place. After exposure, the TLD is "read" at the same time as a control TLD that accompanied the wearer's dosimeter in transit is read, and the results compared with a calibration standard. These independent measurements of exposure to the same type of TLD permit an evaluation of the net exposure as a function of type and of energy of the radiation. TLD rings are also employed, and they function in the same manner.

> Small ionization chambers of indirect or direct reading types are available. These devices known as "pocket chambers" or "pocket dosimeters" are miniature ionization chambers with a range of 0-200 milliroentgen, full-scale. They are for x and gamma radiations only.

Other personal measuring devices can be obtained. Contact the RSO in this regard.

With the single personal monitoring device, the intent is to infer exposure to the whole body. The whole body as the critical organ is defined to include the blood forming cells, gonads, and lenses of the eyes. Obviously, the single detector can only suggest the magnitude of the whole-body exposure.

Those operators of x-ray equipment who may experience an exposure to the lenses of the eyes greater than the detector under the apron will "see" should request an evaluation of exposure to the lenses of the eyes from the RSO. An health physicist will evaluate the exposure conditions and, if warranted, will arrange for a second detector to be worn at a convenient location outside of the area covered by the lead apron which will be responsive to the exposure received by the eyes.

Occasionally, a badge holder will become contaminated with minute quantities of radioactive material. When this occurs, the report of exposure will show an unexpected increase, and the suspected presence of contamination will be reported by the supplier. These badge holders shall be taken from service and replaced by the RSO.

2.2.4 Medical Examinations and Bioassays

When deemed necessary by the RSO and agreed to by the campus administration, or as required by Federal or State regulations, a medical examination or special bioassay procedure may be ordered for individuals who will be working with materials or equipment producing ionizing radiation. Such additional procedures will require an amendment to the radioactive materials license. Any question of the need for a physical examination should be brought to the attention of the RSO.

*The following is for **information only**. **No** license condition for bioassays is currently in effect. When tritium is used in uncontained form, a bioassay of a urine specimen is required for each person involved with handling the material in the following amounts:*

* *For tritium as HTO in quantities of 1000 mCi or more, a bioassay shall be performed within one week of single contact and bioassays shall be performed weekly for continuous contact.*

* *For tritium as a labeled organic compound in quantities of 100 mCi or more, a bioassay shall be performed within one week of single contact and bioassays shall be performed weekly for continuous contact.*

* *For tritium as a labeled organic in quantities of 10 to 100 mCi or as HTO in quantities of 100 to 1000 mCi, a bioassay shall be performed quarterly for single or intermittent contact.*

For users of tritium in quantities greater than ten millicuries in organic form or 100 millicuries as HTO, the RSO will review periodically the investigator's records of use to insure compliance with any license condition. Arrangements for the delivery of the urine specimens for counting are to be made by the investigator with the assistance of a health physicist.

Contact with radioiodine also requires that a bioassay be performed. This bioassay is to be performed about 24 hours after the contact by means of a gamma-sensitive detector placed close to the thyroid gland. Such bioassay shall be performed within the week following contact with five or more millicuries of iodine-125 or iodine-131 in uncontained form. Where a strong suspicion of thyroid dysfunction exists, a urine specimen shall be analyzed.

Each investigator for whom these bioassay requirements apply will be urged to reduce individual contact with uncontained tritium and radioactive iodine to minimize the number of bioassays to be performed. For example, an investigator who keeps a supply of more than one curie of tritium as HTO but uses only 500 or so millicuries for each experiment, can at one time divide the more than one curie into aliquots of less than one curie each which will then require but one bioassay.

Additionally, bioassays may be required by the RSO when large quantities of other materials are handled in an uncontained form.

2.2.5 Supervision and Instruction of Personnel

All operations in which there is the possibility of exposure of faculty, staff or students to ionizing radiation shall be supervised by technical personnel who are aware of the radiation hazards and of the means to minimize them. These persons will usually be the ones who have been licensed to use the radioactive material or radiation source. The supervisor (generally the licensed user) shall function as the "laboratory safety officer" by insuring compliance with the campus rules and regulations as well as making certain that the requirements have been posted and brought to the attention of all subordinates.

2.3 AREA RADIATION CONTROL

Adequate area radiation protection and control of contamination are dependent on proper laboratory design. This includes the proper location of fume hoods or glove boxes, and proper layout of work

and counting/reading areas; the use of appropriate construction materials; and the establishment of safe, workable, laboratory routines. Most applications involving radioactive materials conducted on the campus may be accomplished with very ordinary equipment. If in doubt about the use of specific items of equipment, contact the RSO.

The authorization to use materials under the campus license conveys with it a specific place of use. The user **shall not vacate** this place of use without clearance from the RSO attesting release to unrestricted use, **nor shall the user move** to a new location without the approval of the RSO and EHS Manager **following** any necessary license amendment.

2.3.1 Equipment

Surface materials used in construction of laboratories should be of an impervious type. Laboratories that have been converted for the use of radioactive materials may be used subject to approval of the department involved, the RSO and the administration. Materials are available that may be used to seal existing pervious surfaces. As a minimum, work surfaces should be protected with a disposable covering. Such supplies must be obtained by the laboratory through regular purchasing procedures.

Laboratory operations involving more than low-level activity shall be conducted within fume hoods that are designed and operating properly. Any fume hood not providing a minimum air flow of 100 linear feet per minute measured with the sash half open is not adequate for work with radioactive materials and shall not be used unless limited use has been approved by the RSO. Glassware, pipettes, gloves, and other laboratory apparatus when once used with radioactive materials shall be reserved for such use and shall not be mixed with "clean" equipment nor returned to stock. It is preferable that they be stored in a separate cabinet or special radiation shielding container that is so labeled.

Fume hoods, glove boxes, or other enclosures intended to control or contain particulate or gaseous forms of radioactive material need not be filtered unless the quantity in use is large enough that Maximum Permissible Concentrations (MPC) set by 10 CFR 20.105 are exceeded at the discharge point. If particulate matter is present in sufficient quantities to exceed MPC values, a suitable filter placed in an accessible portion of the exhaust duct is indicated. Since a particulate filter is ineffective for a gaseous effluent, other arrangements to reduce the output at the exhaust point must be made when high concentrations in the gaseous form are expected. A license amendment must be sought if modifications are significant.

2.3.2 Area Monitoring

Each laboratory shall have a survey meter or laboratory monitor **readily available** to it that is capable of detecting radiation from the material in use. Laboratories using small quantities of weak beta emitters such as tritium or carbon-14, exclusively, are exempted from this requirement. This instrument shall be used to monitor all operations involving radioactive materials. All equipment used in the operation and all areas subject to contamination should be monitored before and after use, and an appropriate entry should be made in the user's log book or posted to document the results of the survey. These surveys are the responsibility of the authorized user, and any uncertainty about what

is required should be resolved by consultation with the RSO. The RSO may be contacted to provide assistance in establishing the proper method of surveying and the procedure for recording results.

Contaminated equipment or surface contamination shall be so labeled until decontaminated. See Section 2.6.5 for an identification of the proper kind of label to use. All plumbing and exhaust air ducts in laboratories using radioactive materials shall be monitored before undertaking repair. Sink traps, piping and ducts that are likely to be contaminated shall be so labeled.

2.3.3 Contamination Levels and Decontamination

In any laboratory where radioactive materials are used in an active research program, it is inevitable that minor spills or other forms of contamination will occur despite the best efforts to prevent them. The prompt attention of the user to the decontamination of these minor spills will minimize the hazard and result in the maintenance of a "clean" laboratory. At times, even these minor spills will resist all normal efforts for decontamination. If such is experienced, the RSO shall be contacted for assistance. Special complexing agents are available to aid in removing the persistent attachment of some chemicals to surfaces.

Occasionally, a more serious contamination problem will result from an accident or from an unexpected development of the experiment being performed. In this situation, the person conducting the experiment shall immediately institute the emergency procedure outlined in Section 2.4 below as adapted to the circumstances. It will be necessary in every instance to notify the RSO to provide an evaluation of the degree of hazard involved. The University is obliged to report to the NRC any incident of contamination or radiation exposure that exceeds certain levels defined in the Federal regulations. The RSO will determine whether or not the specific circumstance or exposure exceeds these limits.

2.3.4 Special Problems Related to Use in Animals

The use of radioisotopes in animals is not anticipated. If such use is contemplated, contact the RSO for the requirements, which will include a license amendment.

2.4 EMERGENCY PROCEDURES

2.4.1 Definition

The term "emergency" refers to any incident resulting from the use of radioactive materials in the operations of the campus that presents an internal or external hazard to persons. Such an incident may vary in magnitude from a simple spill of low-level activity in a laboratory that is relatively easy to clean to a fire or explosion that disperses quantities of radioactive material over a wide area. The materials involved may be dusts, liquids, gases, or vapors.

2.4.2 Procedure

The procedure to follow is posted in each room where the use or storage of radioactive material is licensed. The basic steps are:

(1) If fire is involved, call 911 immediately. Campus Police will respond along with the community fire department personnel and equipment.

(2) Minimize radiation exposure to personnel by evacuating them from the area involved to an isolated area, **but** keep them at the nearest safe location until they can be checked for contamination.

(3) Pull building fire alarm.

(4) Notify the supervisor of the laboratory.

(5) Notify the EHS Manager through the Police Office (516-5155).

(6) Post warning signs and allow no one to enter the contaminated area unaware of the hazards.

(7) If requested by the RSO, use absorbent material to limit the spread and volatilization of a radioactive liquid spill.

(8) If requested by the RSO, close windows, doors and vents. Leave fume hoods running, but have Facilities Services turn off ventilation.

(9) Assist the RSO in monitoring personnel and completing their decontamination.

(10) After the emergency is over and all hazards are under control, assist in preparation of appropriate report forms.

2.4.3 Area Decontamination

Decontamination shall be accomplished by laboratory personnel under the supervision of the RSO. This means that the labor required to effect the decontamination and the expense of special materials and services needed to implement the decontamination may be charged to the laboratory requiring the service.

2.4.4 Personnel Decontamination

When an individual is injured as a result of a laboratory accident, the first consideration should be to seek medical attention for the victim. If, however, the individual has been contaminated with radioactive material as a result of the accident, the following steps should be considered:

* Persons splashed with radioactive solutions should wash or be washed immediately with ample quantities of water. A mild soap may be used.

* If radioactive material has been swallowed, after transferring the person to a suitable clinical facility, a stomach pump may be used by medical staff to remove the ingested material.

* The attending physician should be informed of the likelihood of ingestion or inhalation of radioactive materials since they are extremely dangerous when taken internally. The physician also should be advised if the patient represents a significant radiation hazard to those in attendance.

2.5 OTHER SOURCES OF RADIATION

2.5.1 General Precautions

In a broad sense, a source of radiation may be an x-ray generator, an electron microscope, a naturally occurring radioactive material, a reactor, an accelerator, or a byproduct material. Most specific instructions given in this handbook relate to radioactive materials, both naturally occurring and artificially produced. However, this emphasis on radioactive materials is not intended to exclude the equally important need for control of radiation hazards engendered by operation of machines which produce ionizing radiations. In keeping with the ALARA commitment, any requirement set forth herein for the safe use of radioactive material is to be interpreted as applying to all other sources of ionizing radiation.

Basically, radiation producing sources are to be installed and used in a way that will not endanger life or property. This criterion is satisfied if the installation of the radiation source is made with provision for adequate safeguards such as radiation shielding, remote operation, restricted accessibility, and so forth. All ionizing radiation sources within the operations of the campus will be inspected to determine that this basic criterion is satisfied effectively. Any new installations of radiation sources should be reviewed by the RSO to insure compliance with pertinent regulations.

2.5.2 Regulations

All sources of radiation that are not covered specifically by the Code of Federal Regulations are covered by the State of Missouri Radiation Protection Regulations. Federal control is exercised over reactors, byproduct materials, source materials, and special nuclear materials as defined by the Federal regulations. X-ray generators, accelerators, and naturally occurring radioactive materials are controlled by the State of Missouri. Within the university, no distinction is made to the origin of the controlling regulation since the same standards of radiation safety have been applied to both.

2.6 RECEIPT, STORAGE AND USE OF RADIOACTIVE MATERIAL

2.6.1 General

Details of the State and Federal regulations pertaining to receipt, storage, and use of radioactive materials can be made available by the RSO at the Universities expense. These requirements are consolidated and summarized below for the convenience of the reader. If the statements to follow are not sufficiently clear or detailed to provide guidance and if the specific regulation is unclear as to what to do, the investigator should consult with the RSO to establish a proper interpretation of the regulation.

2.6.2 Procedures for Opening Packages Containing Radioactive Material

The Federal regulations require among other things that "Each licensee shall establish and maintain procedures for safely opening packages in which licensed material is received, and shall assure that such procedures are followed and that due consideration is given to special instructions for the type of package being opened." If an individual investigator receives a misdirected package, he or she shall telephone the EHS Manager immediately.

Incoming shipments are **not** delivered to the intended user if there is any obvious package leakage, damage or discovered removable contamination. Licensed users and their trained assistants (radiation workers) are authorized to open packages, and this will be accomplished as though the inside of the package were contaminated. The general procedure to be followed is:

(1) Re-inspect package for integrity and for evidence of leakage.

(2) Monitor external surfaces for contamination and exposure rates.

(3) Check labels and shipping papers to insure the shipment is to the correct address and contains the intended activity and isotope.

(4) With gloved hands, open the outer container. Packages containing more than ten millicuries should be opened in an operating fume hood or glove box.

(5) Inspect the inner container for integrity and for evidence of leakage.

(6) Monitor packing material and wipe-test inner container for contamination.

(7) Dispose of uncontaminated outer containers and packing materials as ordinary waste **after** removing or obliterating the radiation signs or labels. Contaminated packages and packing material shall be handled as radioactive waste.

(8) Open inner container in accordance with manufacturer's instructions.

(9) Label all radioactive materials and enter receipt in user's inventory.

Immediately notify the EHS Manager of any contamination or other problems associated with the delivery, receipt, or opening of packages containing radioactive materials.

2.6.3 Records to be Maintained

Most records required by State or Federal regulations are maintained by the RSO; however, some must be maintained by the licensed user. Among the records to be maintained by the RSO are the quantity of radioactive material currently licensed for each user and the amount currently in their possession. The current inventory of each user must not exceed the limits set by the license. Details of the day-to-day possession and use must be maintained by the laboratory personnel.

The individual user must keep a record of the receipt, use, storage, and disposal of radioactive materials so that amount on hand can be calculated at any time. For those investigators using a sealed source, an adequate inventory need only be an accessible record of the date of receipt of the material with a reasonably accurate assay of the original activity. With this data, the quantity remaining at any future time can be estimated by calculation of the exponential decay.

The investigator receiving a shipment of material that is to be introduced in toto into an experiment has a relatively simple task. The inventory need consist only of the pertinent data of receipt of the material and the date of introduction into the experiment. From that point in time, the quantity on hand is the quantity in the experiment, and unless some material is lost from the experiment, the quantity on hand at any future time is the original amount reduced by radioactive decay.

The investigator who plans to share material with another licensed user must first notify the RSO in order that each user remain within hie or her authorized possession limits or in order to amend the license if the added user is not currently licensed to possess such material. If the transferral is ultimately authorized, both individuals must appropriately record the transfer and adjust their inventories.

Forms have been developed upon which daily use and inventory records may be kept. A supply of these forms may be obtained from the RSO. The RSO will initiate requests for **semi-annual inventories**. Instruction in the procedure for maintaining an adequate inventory is provided to each new user by the RSO.

A new radioisotope receipt form (SLHP- 3SP) is given to the user with every delivery of material. The activity delivered is determined by the RSO and inventorying is relative to that quantity. Exact values cannot always be given for each step in the user's procedure, but reasonable estimates must be provided. Every investigator should be so familiar with what has happened at each step of his or her procedure that an estimate within twenty percent of the actual **undecayed** amount can be made.

2.6.4 Waste Disposal Procedures

Most of the information about the transfer and disposal of radioactive wastes that may be of importance to an investigator is contained in Section 4. All intentional disposal must be accomplished by or under the supervision of the RSO. Any material transferred to the RSO for disposal must be identified by inventory number, isotope, quantity of material, radioactivity (undecayed), and chemical hazard, if any. Radioactive waste (Radwaste) is considered part of the user's balance on hand until physically removed by a member of the RSO's staff. A record of the transfer must be made in the user's log and deducted from the inventory balance.

2.6.5 Posting of Warning Signs and Notices

Parts of the State and Federal regulations with which the university must comply stipulate a system of warning signs and notices to be posted. These warning notices are available from the RSO as made available by the EHS Manager. A copy of the current version of the Form NRC-3 "Notice to

Employees" must be posted in every laboratory using byproduct materials licensed by NRC. This form is to be posted so that every employee of the laboratory can read it conveniently. It need not be posted on a departmental bulletin board.

Rooms in which radioactive materials are to be used on a routine basis need to be identified by affixing to all entrance doors a warning sign containing the words "Caution-Radioactive Material" and the three-bladed radiation (propeller) symbol. These are available from the EHS Manager. Other wording appropriate to the use of the room may be added, but nothing less than the above with the symbol is acceptable. Irrespective of the presence of the warning labels, the investigator shall secure the material from unauthorized access. If radioactive material is normally kept within a closet and the material is brought into the room for short periods only, the closet door should have the warning sign affixed, but the door to the room itself may be left unmarked. Rooms in which radioactive materials are no longer in use will have the sign removed **after** a closeout survey has been performed by the RSO.

Containers in which radioactive materials are stored must be labeled as to isotope, form, quantity of material, and radioactivity. The containers shall also have affixed to them the standard "Caution-Radioactive Material" label plus the unique inventory number assigned when the material was received on the campus. Containers such as beakers, tubes, flasks, and similar devices need not be labeled as long as the radioactive material kept in them is used within the same day, they are kept separate from other containers, and the investigator is present during the time the material is being used.

An "Emergency Procedure" appropriate to the work in the laboratory shall be posted and its contents made known to all staff normally working in the laboratory. This procedure may be constructed from the general procedures of Section 2.4.2. A standard procedure form is provided by the RSO, but details specific to the laboratory should be added by the user.

Special labels are required by State regulation to be affixed to x-ray generators. This label also is available from the RSO or EHS Manager. It shall be placed at or near the control panel so that it is clearly visible to any person in the vicinity of the unit.

2.6.6 Leak Testing of Sealed Sources

All sources of radioactive material, whether byproduct material or not, which have been encapsulated to prevent the escape of the contained material shall be checked within six-month intervals to insure the integrity of the containment if the activity is calculated to be 1 uCi or greater. Sealed sources designed for the purpose of emitting alpha particles shall be tested for leakage within three-month intervals. Foils for gas chromatographs, containers of radioactive material in gaseous form, and external standards used in counters are not considered to be sealed sources unless they are removed from the unit. To provide for a uniformity of testing procedures and to assure compliance with the Federal and State regulations pertaining to sealed sources, the RSO will leak test sealed sources according to an appropriate schedule. Reports of leak tests will be forwarded to the licensed user and the EHS Manager.

2.7 CRITERIA FOR ADEQUATE CONTROL

2.7.1 General

Standards for adequacy must be based upon the qualifications of the people using the materials and upon the relative risk of the operation. Neither of these considerations can be defined rigidly, nor can exact yardsticks be applied to the measure of control achieved. Absolute control of radiation hazards is possible only by eliminating all sources of radiation. The university is committed to achieving the lowest risk of exposure without stifling legitimate use.

The degree of control achieved is measured by the RSO as a result of inspecting laboratories, reviewing experience in users following procedures, reviewing experience in emergency actions, and summarizing the results of dosimetry. A prescribed procedure is followed to assess the adequacy of the investigator's methods of use of materials. This procedure includes an assessment of radiation exposure rates, contamination levels, individual exposure records, security and labeling of radioactive materials, use of radiation safeguards, inventory records, qualifications of subordinate personnel, and so on.

Discrepancies that are noted will be reported to the investigator. Specific recommendations will be made to improve the methods when necessary. No instance of non-cooperation with the recommendations of the RSO ever has been experienced. If a negative response were experienced, the issue would be brought to the attention of the user's department head and the campus administration. In general, the degree of control is a relative quantity, and only the repetition of minor infractions or the existence of major items of non-compliance would suggest a lack of control.

2.7.2 Risk-Level Classification

All rooms in which sources of radiation are used by an investigator are assigned a risk-level classification to establish a health physics inspection frequency. Inspections by the RSO are **in addition** to those provided routinely by the investigators. Four categories are defined:

I. **Very-high risk** - This assignment is made whenever the investigator is using relatively large quantities of certain materials or materials of a chemical or physical form such that there is present a constant or nearly constant risk of serious overexposure of personnel or a risk of loss of material or loss of use of equipment or space. An investigator authorized for use of materials at this risk level must have demonstrated to the RSO by evidence of training and experience that the risks associated with the experiment can be minimized. The RSO staff must assist in achieving the necessary control by providing guidance in the design and conduct of the experiment. Both the investigator and RSO must monitor the experiment as often as necessary to maintain control, and the RSO must be prepared to extend special assistance to the investigator in personnel monitoring, decontamination, and waste disposal. Category I risk-level laboratories are to be inspected daily, if necessary, but at least weekly on a routine basis.

II. **High risk** - When an investigator has an on-going project using large quantities of material, or lesser quantities of more toxic materials, and the experiment is well defined and in a steady-state condition, the health physics inspection frequency can be reduced. Similarly, in situations where the quantity, type, or form of the material in use are not sufficiently hazardous to justify a category I classification, the inspection frequency can be reduced. Category II laboratories are inspected monthly to quarterly.

III. **Medium-risk** - This is the category in which most laboratories of the campus are placed. It is assigned on the basis that a non-trivial risk is involved, but the quantity, type or form of the material being used could not, in a worst case scenario, present a serious threat to health or value of property. A quarterly to semi-annual inspection schedule is adequate for laboratories assigned this category.

IV. **Low risk** - Some laboratories are used for experiments in which the quantity, type or form of material are within the limits set by the NRC for a specific license. These may be "exempt" quantities to anyone without a specific license and generally do not constitute a significant threat to health or value of property. While an annual inspection frequency may be appropriate to category IV laboratories, they normally will be inspected semi-annually.

Among the sources of radiation not covered by Federal regulations but for which some control must be provided because of the risk potential are x-ray machines when in use. Once installed, these machines have essentially constant radiation characteristics and do not need to be inspected more frequently than once each year. Rooms in which x-ray machines are operated are assigned a category IV risk level even though very high dose rates can be present.

Another subclass of category IV are rooms **only** used for storage of sealed sources or for use of gas chromatographs with foils. The sealed sources are leak tested within six-month intervals, and the room is inspected accordingly. Gas chromatographs using foils do not require an inspection, but they do require a location check periodically to document that they are operated at the place specified in the license. An annual visit is sufficient for this purpose, and a wipe sample for removable contamination can be taken as an additional safeguard.

It should be noted that the risk-level classification is not related directly to the classification of degree of hazard referenced on page 1-3. Many factors are involved in the risk-level classification and only one of them is the relative hazard described by the chart. In reality, a more important consideration is the attitude of the investigator towards the maintenance of radiation safety in the laboratory. A careless or unconcerned investigator can easily transform a minor risk into a major risk, and such a laboratory will be inspected more frequently.

3. PROCEDURE FOR LABORATORY INSPECTION

August 2002

3.1 GENERAL

This Procedure is one generally agreed to by health physicists in university settings. Variations desired by the individual user are to be discussed with the Radiation Safety Officer. Proposals for these variations are to be accompanied by justification to explain why the variations are necessary.

Instruments appropriate for the measurements to be made must be available, in good working order and calibrated against reference standards with radiation properties essentially equivalent to those being measured. Survey instruments to be used are to be calibrated at least annually and after repair. Operational checks of the survey instruments are performed prior to each use to insure proper operation. Where reasonable, check sources are employed before each use of the instruments to verify response to radiation.

Inspections of laboratories in which radionuclides are used are conducted by the RSO as outlined in Section 1.3 and in compliance with the requirements of 10 CFR 20.201 and 20.401. These inspections are performed on a periodic basis predetermined by the RSO in accordance with the risk-level assigned. Results of these inspections are reported on the Radiation and Area Contamination Survey Form and supplemented by the Laboratory Inspection Checklist.

Leak tests are to be performed at intervals not to exceed six months for sealed sources containing beta, gamma, or neutron emitters, and every three months for sealed sources designed to emit alpha particles, when the estimated activity exceeds 1 uCi. Results of these leak tests are reported on the Report of Leak Test of Sealed Sources form or its equivalent. If it is uncertain whether or not a source is a "sealed source" requiring a leak test, the user should continue to leak test the source as though it were until a definite determination can be made by inquiry to the NRC through the RSO. For the purposes of satisfying the license, a source is a "sealed source" only if the NRC defines it as such under the definition contained in 10 CFR 30.4 (r).

3.2 LABORATORY SURVEYS

Prior to inspecting a laboratory, the RSO's health physicist will review the authorization file of the investigator and the reports of previous inspections. A sketch of the laboratory should be used during the inspection. This sketch is to be made on the survey form to approximate scale or a computer assisted drawing and must show the principal features of the laboratory. Other basic information may be recorded on the form before the inspection is performed. Contact is to be made with the user to schedule the inspection.

A review of the reports of previous inspections prior to the visit will permit a visualization of specific items for which to look in the coming inspection. Of particular interest are any recommendations made previously in order to determine if they have been followed.

3.2.1 Inspection Procedures

Upon arrival at the laboratory, the health physicist will review the following items with the user or the user's radiation worker, who is familiar with the operations of the laboratory.

Availability of Survey Instruments and Record of Use - As required by Section 2.3.2, each laboratory shall have a survey meter or laboratory monitor readily available that is capable of detecting radiations from the radioactive materials in use. The health physicist will check the operational status of the instrument, and review the maintenance, calibration, and use log. Any significant radiation dose rates measured or other anomalies will be noted in the comments portion of the inspection form.

Proposed Use and Special Equipment - Any significant changes or deviations from those stated in the license shall be noted. This may involve some judgment on the part of the inspector. For example, if there need for special equipment, such as, a glove box, remote pipette, or secure storage facility, which is not available.

Inventory Records - The log book maintained by the licensed user will be reviewed for proper entry of receipt, use, transfer, and disposal of radioactive materials. Data should be kept on the Radioisotope Use Log form and the User Inventory of Radioisotopes form or their equivalents. Each authorized user is accountable for any incidental or accidental release of byproduct material to the sanitary sewer. As specified in Section 4.3.3, no release in excess of that resulting from washing of glassware is permitted. Special instructions in methods to minimize release to the sanitary sewer are provided by the RSO. The security of stored radionuclides will be reviewed. Each user will maintain an inventory of byproduct materials in use and will supply signed inventory forms to the RSO upon request.

Area Contamination Control - The inspector will review all procedures for handling radioactive materials from receipt to disposal and check for availability and proper use of radioactive waste containers, absorbent paper, protective trays, and other required items.

Posting and Labeling - Verification of the proper posting of the entrances to the laboratory, the fume hood, the storage area, and equipment as well as proper labeling of containers will be made.

Personnel Monitoring - Use of TLDs for personnel monitoring in each laboratory must be evaluated in terms of the information received. If previous dosimetry records reflect no significant exposures, if the laboratory inspection yields no significant radiation or contamination levels, and if the use of the radionuclides authorized for the laboratory is such that a significant exposure is unlikely, the RSO may consider canceling personnel monitoring for the laboratory. If this step is taken, the use of area monitoring dosimeters affixed to a wall, bench top or other suitable location to serve as area monitors should be evaluated.

Training - The Statement of Training and Experience for Use of Radiation Sources form for each of the subordinate personnel employed in the laboratory who actually handle radioactive materials must be on file. The absence of this record is to be noted, and the steps necessary to obtain this information must be discussed with licensed user.

3.2.2 Survey Procedures

Radiation Survey - For laboratories in which radionuclides emitting both beta and gamma radiations are licensed for use, the radiation survey is to be performed with a Geiger-Mueller (GM) survey meter equipped with side-window (thickness less than or equal to 30 mg/cm^2). One with a shield for beta discrimination may be of special utility. For those laboratories in which radionuclides that emit only beta particles are used, the survey meter should be equipped with a thin end-window or pancake probe (thickness less than or equal to 2 mg/cm^2). Laboratories in which radionuclides emitting alpha particles are used, the survey is to be performed with a suitable alpha-particle counter. Where radionuclides that emit neutrons or where neutron-producing devices are used, the survey will be performed with a neutron-sensitive instrument equipped to differentiate between energy groups, so that a separate measurement of each can be recorded.

In performing a survey, special attention is to be given to the following locations: storage enclosures, fume hoods, glove boxes, waste containers, work surfaces, sink basins, and the floor around each of these components. If the dose rates are less than 0.05 mrad/h or the predetermined background, the following statement may be entered on the survey form: "DR < 0.05 mrad/h" or "B" for background.

Contamination Survey - Evaluation of the wipes (smears) collected in laboratories using beta-emitting radionuclides is to be made with either a shielded GM meter, or a gas-flow proportional counter calibrated for detection of betas. Wipes taken in laboratories using weak beta emitters will be evaluated with a liquid scintillation analyzer, if available, or a thin-window gas-flow proportional counter. Wipes from laboratories using alpha emitters are to be evaluated with a gas-flow proportional counter calibrated for detection of alphas, or a crystal or junction detector.

The wipe sample for removable contamination will be taken from an area of approximately 100 cm^2 using discs of appropriate material suitable for the dimensions of the counting device. To prevent cross contamination among samples, each is to be placed in a separate labeled envelope. In some instances, it may be desirable to moisten the paper disc with a detergent solution or other solvent to enhance the collection efficiency.

When performing a contamination survey, special attention is to be given to the locations identified in the radiation survey where higher radiation rates were obtained as well as to laboratory entrances and exits. Results of the evaluation of all wipes can be reported in pCi or dpm of removable contamination per 100 cm^2. If the evaluation of the samples indicates the absence of removable contamination, the notation NCE may be entered on the survey form as an abbreviation for "no contamination evident." The detection system used to evaluate the wipes must be documented, and the sensitivity of the detection system should be retained on file and periodically checked.

Fume Hood Air Flow - The air flow through a fume hood in which radionuclides are used will be measured with the hood sash half open and according to campus protocol. The face velocity of the hood should be measured under conditions of actual use. There must be a uniform air flow of at least 100 lfm, averaged over the face of the hood opening, but not greater than 150 lfm. The value is to be recorded on the inspection form. The instrument used to measure the air flow will be identified.

While measuring the air velocity, the inspector will examine and evaluate the materials and construction of the hood for adequacy.

The requirement of a minimum air flow rate in fume hoods can be modified at the discretion of the RSO upon evaluation of the isotope, quantity, the form being used, and a review of the type of experiment being performed. A more definite measure of the adequacy of the fume hood as a safety device is the lack of evidence of removable contamination in the vicinity of the hood. The health physicist must be mindful of the hazards of an airflow rate that becomes too high when the sash is lowered.

The health physicist will evaluate the radioactivity concentration in the fume hood exhaust by dividing the maximum activity potentially airborne by the volume flow rate through the hood face. If the MPC(air) for the nuclide in question is likely to be exceeded at the exhaust, the RSO will determine what needs to be done to reduce the effluent concentration to less than the

MPC(air) values required by 10 CFR 30.104. The RSO's staff should know the location of each fume hood exhaust, should post it with an appropriate label, and should periodically check the occupancy factor in the immediate environs of each. In some instances, a particulate or gaseous filter (or both) may need to be installed to reduce the concentration at the exhaust. The inspector finding this condition will limit the use of the hood until the filter is installed. An amendment to the license may be necessary.

Air Sampling and Bioassays - In compliance with 10 CFR 20.103 (a) (3) and during the laboratory inspection, an air sample is to be collected whenever the radionuclides in use can be suspended in air in sufficient quantities to pose an inhalation hazard, that is, if it is a substantial fraction of the MPC(air). A high volume air sampler can be used to collect the sample over a ten minute or longer period. Lower volume samplers can be used over longer sampling periods. If a radionuclide such iodine-131 is present, a filter or activated charcoal cartridge is to be used.

The start and completion time of the sampling, the average air flow rate, and the activity (in uci/cm^3) are to be recorded on the survey form. A 24-hour recount should be taken to determine if activity other than short-lived, natural radioactive materials are present, and these results are also to be recorded. If the recount indicates activity levels above MPC(air) values, the licensed user is to be notified, and an analysis of the contaminants present is to be made. A recount of the same sample can be made one week later to verify the absence of long-lived contaminants.

Whenever the air sample contains radioactive material in excess of a substantial fraction of the MPC(air), a bioassay of a suitable specimen (thyroid count, nasal smear, urine, feces, etc.) may be required for all personnel who may have been exposed to the contaminated air. The need for a bioassay will be determined by the RSO. The results of these bioassays, even if negative, are to be recorded in the personal monitoring record of the individuals involved. To the extent that airborne contamination by the radioactive material reflects loss of control, remedial steps to restore the control must be taken as soon as possible.

3.3 LEAK TEST OF SEALED SOURCES

The leak test is to be performed with wiping discs or with cotton-tipped applicators, depending upon the source activity, configuration, and containment. The source should be rubbed firmly with the discs held in tongs or forceps or with cotton-tipped applicators, to remove any surface contamination. The source holder also should be wiped. When access to the sealed source is prevented by the construction of the device, the wipes should be taken as near the source as possible. Each disc or applicator must be placed in a separate envelope and appropriately identified.

Evaluation of wipes taken from sealed sources containing a beta emitter should be made with a shielded end-window Geiger-Mueller counter, or equivalent. Evaluation of wipes taken from sealed sources containing an alpha emitter should be made with a gas-flow proportional counter, or equivalent. If the results of the test indicate a removable contamination in excess of 0.005 uCi, the source will be taken from service immediately and held in secure storage until the cause can be determined and the source decontaminated or removed for disposal. When leak tests are performed by a user, the wipe sample is taken according to instructions provided by the RSO, who subsequently counts and evaluates the sample that is returned.

A warning tag is to be permanently affixed to any sealed source which can be removed from its storage container. The tag shall be at least one-inch square and bear the radiation symbol and the instructions: DANGER - RADIOACTIVE MATERIAL - DO NOT HANDLE - NOTIFY CIVIL AUTHORITIES IF FOUND. The RSO shall impound any source not satisfying this requirement until a suitable tag can be affixed.

3.4 REPORTS

The results of the inspection as reported on survey forms are to be sent to the authorized user as soon as possible after evaluation of the inspection. If the inspection reveals conditions that require correction, a follow-up survey is made after a reasonable period of time has elapsed. However, if the conditions are such that immediate attention must be given to them, a the RSO immediately shall notify the user and the EHS Manager and assist in correcting the situation.

In preparing the report of an inspection, the RSO must weigh carefully the information that has been accumulated to determine if a specific recommendation should be made to the investigator. It is not sufficient merely to report radiation levels or contamination levels. The numbers also may provide a measure of the response of the investigator to university regulations and to the general recommendations of this handbook. The RSO can decide whether or not the investigator is doing all that can be expected to maintain exposures ALARA.

A health physicist will develop a sense of adequacy of radiation safety after visiting the same laboratory several times. Present conditions can be compared with those of the past and with those found in other laboratories. This buildup of experience with the laboratory along with the response of the investigator to recommendations for correction of unsatisfactory conditions permits the health physicist to make value judgments that need not be tied to an arbitrary scale of safe or unsafe conditions. As an example, removable contamination of 10 pCi/100 cm^2 of a beta emitter in one

laboratory may reflect a greater lack of attention to good practice than a removable contamination of 100 pCi/100 cm^2 of a beta emitter found in another laboratory. At the same time, the health physicist must not allow an increasing familiarity with a laboratory or with the investigator to permit a gradual trend toward increased radiation or contamination levels. Acceptable laboratory practice should be evident, and where found should be made known to the user with the same persistence as poor practice is conveyed.

3.5 ALARA

As low as reasonably achievable as originally conceived by the International Commission on Radiological Protection (ICRP) meant only that good practice should be applied to the solution of problems such that individual and group dose commitments would be reduced. As interpreted and codified by the NRC, ALARA has come to be a condition of licensing. Goals must be established, a program to reach these goals must be specified, and progress toward achievement of the goals must be recorded, or else the program is deemed to be deficient.

The above Procedure for Laboratory Inspection is intended to reflect good practice and to be responsive to the guidance of the ICRP. By itself, it does not satisfy the definition of ALARA as modified by the NRC. Limits set by 10 CFR 20 are not satisfactory as goals, nor are fractions of these limits in a rigid sense, because they may remain above being reasonably achievable. Regulatory Guides 8.10 and 8.18 should be consulted for further information and should be utilized to assess achievement of reasonable goals.

If experience indicates that other action thresholds should be used, then the basis for an ALARA program will be established. In every instance of application of the ALARA principle, the final measure of success is the personnel monitoring record including bioassay data.

4. RADIOACTIVE WASTE DISPOSAL PROGRAM

August 2002

4.1 GENERAL

All radioactive waste (radwaste) resulting from the use of radioactive materials in university laboratories shall be disposed in a manner that will prevent a hazard to the health of persons on the campus and in the community or the loss of property value. Safe disposal is to be accomplished by the RSO through one or more of the following means: storage for decay of short half-life materials, admission of limited and strictly controlled quantities into the sanitary sewer system, or properly contained storage for shipment to another licensed facility.

Radioactive waste, both liquid and solid, resulting from the use of radioactive materials in laboratories **shall** be stored by the user in designated properly marked containers and retained for collection by the RSO. Liquid wastes are to be stored in glass, metal or plastic containers with any additional provisions recommended by the health physicist.

Volume reduction of all wastes has become more important as the costs of disposal have increased rapidly and the availability of disposal sites has diminished. Volume reduction begins at the user level when decisions are made as to the quantities and types of material to purchase. This consideration must be applied when the experiment is designed.

Radwaste collected from each laboratory will be stored in the campus Dangerous Chemicals Storage Building Radioactive Materials Storage area (DCSB-RMS) where the material can be retained for a sufficient interval to permit the decay of short-lived constituents. All wastes that cannot be disposed by decay or released into the sanitary sewer will be shipped to a commercial facility for incineration or burial.

Radionuclides requiring a "Radioactive Materials" or "Radioactive Waste" label may be stored only in specifically designated areas and must be protected against fire, explosion, and water damage. The areas must be locked and under the control of responsible individuals. Documentation must be available listing all nuclides present, the activity as of a specified date, and the generators of the material. Material requiring refrigeration can be stored in flammable liquids or explosion proof refrigerators. A fire extinguisher must be located nearby. Adequate shielding against accidental exposure must be provided.

For information purposes only, it is noted that a special disposal problem is created by the use of radioactive materials in studies involving animals. Besides the problem of disposing of carcasses containing radioactive materials, there may be a problem of disposal of excreta. Normal methods of disposal of animal excreta are not permissible when the excreta are contaminated by radioactive materials. The investigator is required to contact the RSO if usage in animals is being considered. An amendment to the license may be necessary.

4.2 CAMPUS WASTE HANDLING FACILITY

As stated above, the campus facility for radwaste storage is the DCSB-RMS. Although not

anticipated, materials transported outside of the contiguous boundaries of the St. Louis campus are to be packaged and transported in compliance with the applicable parts of 10 CFR 71.5 and 49 CFR.

- CONTAINMENT: Solids for shipment off-sight for disposal are to be stored in 12-gallon fiberboard drums, 1.5 cubic feet corrugated cardboard boxes or 55-gallon steel drums. All must be lined with at least 4 mil plastic bags or plastic inserts. Liquids are to be stored in vials (glass or plastic) and bottles up to one-half liter inside the plastic liners with sufficient absorbent material to absorb at least twice the quantity of liquid placed in the outer container. Animals or biological tissues are to be kept frozen prior to shipment off campus. Specific but equally effective containment may be arranged with a permitted and licensed radwaste transporter.

- SURVEYS: All packages to be shipped should have dose rate readings of less than 200 mrad/h at any point on accessible surfaces and less than 10 mrad/h at one meter from any external surface. There shall be no significant removable contamination on the exterior surface of the container.

- IDENTIFICATION OF SHIPMENT: Each package shall be identified by attaching a radiation warning label or tag giving the following information: each and all radionuclides contained therein; each associated activity with the date for that activity; dose rate at the surface of the package and dose rate at one meter from the surface; the date the outer container was filled; and the identification of the person completing the label or tag. The package also will be labeled as required by 10 CFR 20.203 (f) and 49 CFR. A shipping manifest shall be prepared listing the number of packages, the contents of each in terms of radioactive nuclides and associated activity, physical form, and date shipped. One copy of the manifest shall be kept by the RSO, and the original with the remaining copies shall be given to the driver.

Hazardous materials are by definition different from radioactive materials. Hazardous waste, as defined by the U. S. EPA in 40 CFR 261, that is also radioactive must be handled separately. These wastes must be prepared to meet EPA and State requirements. Such combination of materials for investigative purposes is strongly discourage, and the investigator must contact the RSO prior to preparing or using mixed-hazard materials.

4.3 RESPONSIBILITIES OF THE RADIATION SAFETY OFFICER FOR WASTE DISPOSAL

The responsibility for the collection, storage, and ultimate disposal of laboratory wastes contaminated with radioactive materials belongs to the RSO. This provides single-point control of waste leaving the campus. To effect this control, all disposal by decay, release to sewer, or by shipment to a permitted facility shall be performed only by the RSO's Health Physics (HP) staff.

4.3.1 Laboratory Wastes

The HP staff will supply the laboratories with leak-proof containers of not more than 12 gallons capacity with plastic liners. These containers will be labeled "RADIOACTIVE WASTE." Collection

4.4.1 Wastes Accumulated for Collection

The licensed user shall

- Ensure that **only** radioactive wastes are placed in containers designated for such,
- Ensure that all sharp objects (hypodermic needles, broken glass, etc.) are within a puncture-proof encapsulation so that they cannot penetrate the plastic liner,
- Ensure that radioactive wastes are not removed by unauthorized personnel,
- Ensure that waste materials are segregated according to physical state and placed in containers recommended by the RSO,
- Provided with double containment and adequate absorbent for liquid waste as recommended by the RSO,
- Notify the RSO or Manager of EHS when waste materials are to be picked up;
- Be present, if possible, when the health physicist collects the waste material (the health physicist shall not remove wastes which are not identified properly).

4.4.2 Waste Disposal in Laboratories

Radioactive wastes in liquid form shall **not** be poured into the sanitary sewer system. The single exception, as noted above, is the release of trace amounts of radioactivity contained incidentally in the second rinse water resulting from the washing of contaminated glassware and implements. All other liquid wastes are to be accumulated for collection by the health physicist as explained in Section 4.4.1.

4.4.3 Disposal of Animal Carcasses Containing Radioactive Material

The work at this campus involving the use of animals in experimental studies with radioactive material is conducted with small animals. When they are sacrificed, they may be stored under refrigeration until it is convenient to dispose of them. For disposal of carcasses containing radioactive material, the following guidelines are offered.

If the half-life of the radioactive material is short enough to decay as licensed, the RSO should store the carcasses in the central waste facility secure refrigerator long enough to meet the waste decay criteria. After storage, the carcasses should be shipped off campus for incineration at a permitted facility. In case the radioactive material is concentrated within a single organ or localized system, the organ or system may be removed and the above procedure followed. The remainder of the carcass may be incinerated as soon as it has been determined to be free of radioactive contamination.

of waste will be provided at the request of the licensed user or his or her designate or as deemed appropriate by the RSO.

4.3.2 Available Methods of Disposal

Wastes will be separated and stored according to physical form (liquid or solid) and isotope to facilitate the disposal procedures outlined below.

Disposal by Decay - Radioisotope waste (Radwaste) with half-lives less than 90-days can be segregated for decay of at least 10 half-lives to general background. The RSO is responsible for maintaining secure storage at the campus central waste storage facility apart from non-radioactive waste. After the decay conditions are met, the RSO must ascertain that the materials and associated containers have no hazardous waste component in order that the items can be disposed by sanitary sewer or landfill. All indications (labels) of radioactive constituents will be destroyed by the health physics personnel.

Shipment to a Commercial Facility - Radwaste not disposed by the above means will be shipped to licensed or permitted commercial facilities. Such waste includes solid material like wipes, filter papers, contaminated clothing, aprons, and absorbent counter covers. Liquid wastes shall be reduced to minimum volume. They may be collected as liquids or converted to solid form for disposal as agreed to or recommended by the RSO. Solid waste material shall be shipped in 55-gallon drums or other suitable containers in accordance with applicable DOT regulations (49 CFR) and the requirements of the burial site to which the material is shipped. The RSO will be responsible for the management of shipments to commercial facilities.

Disposal into the Sanitary Sewer System - Disposal into the sanitary sewer system is to be accomplished by the RSO or under the RSO's supervision and must be specifically approved under the license. Liquids disposed through the sanitary sewer system must also meet the other requirements of 10 CFR 20.303 and should be limited to those quantities that cannot be economically disposed of by other methods.

Radioactive material released by laboratory personnel shall be limited to that occurring incidentally with slightly contaminated wash water from cleaning laboratory glassware (second rinse water). Any uncertainty about this procedure shall be addressed to the RSO for clarification or for assistance in establishing alternative methods.

4.4 RESPONSIBILITIES OF THE LABORATORY SUPERVISOR FOR WASTE DISPOSAL

Collection and storage of wastes within the laboratory are the responsibility of the licensed user. Compliance with applicable regulations and control of radioactive wastes until such wastes are removed by the health physics staff must be insured by the user. All radioactive waste shall be segregated and properly labeled.

If the animal is small but the half-life of the radioisotope is 90 days or greater, or if refrigerated storage is not available, arrangements must be made with the RSO so that the carcasses can be incinerated promptly at a permitted commercial facility.

Work on large animals would require a license amendment, and special procedures would be detailed in the submittal.

4.4.4 Disposal of Animal Excreta Containing Radioactive Material

A rather complex problem of radioactive waste disposal results from the use of radioactive material for in vivo experiments with animals. The complexity derives from the uncertainty of the quantity and rate of elimination from the animal, the knowledge of which may even be part of the experiment being conducted. Despite these uncertainties, the investigator must be prepared to collect, dispose, and record the quantity of radioactive material contained in all excreta of animals to which radioactive materials have been administered.

The methods by which an investigator proposes to accomplish these tasks are to be made a part of the "Application for Possession and Use of Radiation Sources," described in Section 5.1 of this handbook. The following will serve to outline what needs to be done.

- An estimate shall be made of the portion of the administered quantity of radioactive material that is expected to be eliminated by the animal. From this estimate, the significance in terms of potential hazard to personnel or property resulting from the eliminated material can be evaluated. As a rule-of-thumb, if the total quantity eliminated per day from the entire group of experimental animals is less than ten percent of the values listed for the particular radionuclide in Appendix C of 10 CFR 20, the elimination will not constitute a significant hazard to personnel or property.

- If the evaluation of the potential hazard indicates that a significant quantity is to be eliminated, an adequate method of collection of all excreta must be developed. If a significant activity will not be excreted, the material may be disposed of through normal channels after an evaluation confirms that the excreta are not radioactive.

- After collection of the excreta, the best method of disposal must be determined. The investigator may elect to hold the material in an isolated storage area until a sufficient time has passed to reduce the activity to a negligible level. Upon determination that the residual activity is negligible, the collected excreta may be released to the sanitary sewer system as locally permitted.

- If the material cannot be held for radioactive decay or be released to the sanitary sewer, the disposal must be performed by or under the supervision of the RSO.

4.4.5 Disposal of Gaseous Form Wastes

Some investigations require the maintenance of a breathing environment for plants or animals containing a radioactive material in gaseous form. In all instances, the experiments shall be designed so that the gaseous form of radioactive material is contained within an enclosure exhausted to the atmosphere at concentrations less than the maximum permissible amounts specified in 10 CFR 20 Appendix B, Table I, Column 1. If several radionuclides are released, the limit for the combination may be derived by determining the ratio between the quantity present in the combination and the limit allowed when it is the sole constituent. The sum of the ratios determined in this manner shall not exceed unity.

Records of all releases to air shall be maintained. If a release has, or may have, exceeded the limits specified above, the RSO shall be informed promptly in order to determine if notification of the NRC is required, and if so, to submit all necessary information within the time limit specified.

5. GENERAL INSTRUCTIONS

5.1 APPLICATION FOR USE OF RADIATION SOURCES

The term radiation sources means any material or device from which ionizing radiation is emitted spontaneously or from which ionizing radiation can be produced. Use of byproduct, source, and special nuclear materials by personnel of the University of Missouri at St. Louis (campus) is authorized under the specific license issued by the Nuclear Regulatory Commission (NRC). Control of these uses is dictated by the Federal regulations and by the conditions placed upon the license. Use of certain forms of naturally occurring radioactive materials and machine sources of radiation is authorized in a general sense by the Missouri Division of Health. No licenses are issued by the State, but use is controlled by the Missouri Radiation Protection Regulations. Applications for use of radiation sources on campus property or in the extended operations of the campus shall be reviewed and approved by the Radiation Safety Officer (RSO) through the mechanisms described in Section 5.1.2.

Radioactive materials in normally exempt quantities shall not be used within the operations of the campus without prior approval by the RSO. Investigational use of byproduct materials and accelerator produced radionuclides in human subjects, as for development of new diagnostic procedures in nuclear medicine, is controlled also by the Food and Drug Administration (FDA) through its Bureau of Drugs. Therefore, both NRC and FDA approvals are required.

5.1.1 Guidelines for All Applications

As the designated responsible party in several byproduct, source, and special nuclear material licenses, the Board of Curators must insure that materials procured under the licenses be used in a manner that is as safe as achievable and without adverse consequence for University or community property. As explained in Section 1, the President of the University has delegated to each campus the authority to control the possession, use and disposal of radiation sources covered by Federal licenses and State regulations. On the St. Louis campus, before a radiation source can be acquired, an application must be approved by the RSO **and** a license amendment granted by the NRC.

A critical step in the review process is the determination that the training and experience of the applicant is adequate. Such a determination is critically dependent upon the proposed use, since the kind and quantity of radioactive material or radiation source, coupled with the way it is to be used, specifies the degree of the hazard. (See the discussions of relative hazard in Sections 2.1 and 2.7.) Each application for an authorization to use a radiation source must contain a complete statement of the applicant's training and experience in addition to the proposed kind, quantity and use of the source. The NRC working through the RSO will determine whether or not the statement of training and experience is consistent with the proposed use.

What the investigator hopes to accomplish by use of licensed materials in his experiment is not an issue in the evaluation of the application. The technical validity or substance of the proposed experiment is left for others to judge. However, it is to the investigator's advantage to limit the use to the smallest quantity and simplest form possible to accomplish the desired result.

Qualifications of subordinate personnel who will be handling radioactive material (referred to as radiation workers) are also of concern to the NRC. Such persons must be qualified by appropriate training and experience to perform their tasks safely.

Training sufficient for the proposed use may be obtained by the applicant through formal training, from a preceptorship arrangement by which the training is acquired by working under the supervision of an experienced person, or from collaboration with an experienced person by which applicable experience from another technique may be expanded to include the safe use of a radiation source. The necessary ingredients of acceptable training are adequate coverage of the following topics:

* Principles and practices of radiation safety

* Radioactivity measurement, standardization, and monitoring techniques

* Calculations basic to the use and measurement of radioactivity

* Biological effects of radiation

Courses satisfying all or part of these training requirements are offered in regular academic programs. In addition to the training requirement, the applicant must show that sufficient experience has been acquired in the safe handling of the source for which application is made.

Results of the review of the applicant's training and experience may take many forms. The ideal case is when the applicant has had acceptable training and experience in the same or very similar type of use as is proposed. Then the application can be approved without reservation. A common situation is one in which the applicant has had training and experience suitable for a variety of endeavors but not enough for the use which is proposed. This application can be approved with the condition that another investigator (preceptor) temporarily supervise the use of the radiation source.

The preceptor must have had acceptable training and experience for the proposed use and must assume the responsibility for insuring the safe use of the source. This responsibility continues until the preceptor can report that, based on personal judgment, the applicant can proceed without further supervision. In preparation of the application, the investigator should name the preceptor, so that licensing of the application will not be delayed.

For the situation in which a graduate student will utilize a radiation source in his or her research, an application for license amendment will be submitted in the name of the faculty advisor of the work, and the student will be named in the amendment. Of course, the faculty advisor must be qualified by training and experience. The responsibility for safe handling of a radiation source in graduate research will be vested in the faculty advisor for the project; or if the faculty advisor is not qualified by training and experience, the responsibility will be vested in a third party named in the application who has agreed to supervise this portion of the research. If the graduate student has the requisite training and experience, the application can be filed in his or her name with the subsequent licensing to the student; however, it is preferred that the authorization be issued to a faculty member.

5.1.2 Approval of Applications

Applications for the use of radioactive material sources must be submitted to the RSO. Special forms are required for this purpose, and an application packet is available from the RSO. For the situation in which the investigator is assisted in a significant way by one or more subordinates, the qualifications of these personnel to handle the sources safely should be described as a part of the application.

Upon receipt of the completed application, the RSO will make an initial evaluation of the content to establish that resources are available to support the health physics aspects of the experiment, that no conditions of existing licenses will be compromised by the experiment, and that the applicant has satisfied the intent of University regulations to safeguard health and property. A meeting between the RSO, the applicant, and any other interested parties, may be required. If the application is deficient, it will be returned to the investigator with a written explanation and a recommendation as to the changes needed. When approved by the RSO, the application will be forwarded to the relevant department head for review and then to the Associate Vice Chancellor for Research. All three parties will be required to sign and date the application showing their approval. The RSO will then tender the request for license amendment to the NRC.

5.2 PROCUREMENT PROCEDURES

Only after receipt of notification by the RSO that the license amendment has been received from the NRC may the named user place orders for material or receive material by transfer. Both the ordering and transferring of radioactive material must be approved by the RSO on a case-by-case basis.

Once approval to order is given by the RSO, the supplier must be provided the following information:

- Name of licensed user,
- Type, quantity and form of radiation source desired (not to exceed quantities listed in the license),
- Special shipping instructions, if any,
- NRC license number, when required,
- Name of the RSO and
- The delivery location specified by the RSO.

The licensed user will inform the RSO of the expected date of delivery and the RSO will inform the campus Police.

If the company or agency from which the radiation source is to be ordered is outside of the United States (e.g. Canada, England, or France), a special authorization may have to be obtained from the

country involved. In most cases the special procedures involved in ordering radiation sources outside the United States will be explained in the catalog of the foreign supplier; but if such procedures are not explained, the user is advised to write to the supplier for instructions before the requisition.

Each supplier of Federally regulated materials is required to validate the license to possess and use such material. This is accomplished usually by filing with each such supplier a copy of the pertinent license. Upon receipt of each re-issue of the license, the RSO will arrange for it to be made available to every supplier.

5.3 RECORDS TO BE MAINTAINED

To satisfy the Federal and State regulations, the university must have available for inspection a reasonably current record of all radiation sources in use. These records must be maintained by both the RSO and licensed users. They shall be kept in a form that permits a convenient review by the RSO or by a representative of the NRC. This requirement of the regulations can be satisfied by a simple bookkeeping procedure on forms supplied by the RSO or EHS office. The RSO will require a periodic inventory of the sources on hand; this request will be initiated by the RSO.