HAMILTON COLLEGE
RADIATION SAFETY MANUAL

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FOREWORD

The Radiation Safety Manual represents one part of a commitment by the administration of Hamilton College to keep occupational radiation exposure as low as reasonably achievable (ALARA). It complements organizational units established within the university to provide direction and oversight to activities using radioactive materials and radiation-producing machines.

The pursuit of scholarly endeavors through use of all means available is encouraged, consistent with safe practices that minimize risk to humans and the environment. To this end, adoption of these policies and procedures in research and teaching is fundamental to achieving the goal of ALARA.

The Administration welcomes input from radiation workers about our radiation protection program. Modifications to operating procedures and equipment and facilities will be considered where they substantially reduce radiation exposure at reasonable cost.

President
Hamilton College

A. INTRODUCTION

Ionizing radiation arises from both natural and man-made sources. It's use in teaching and research provides a valuable tool to demonstrate principles and probe the unknown. Hamilton College must operate within the regulations established by the State of New York Department of Health (State Sanitary Code Chapter I - Part 16). This manual constitutes minimum acceptable requirements for use of radioactive materials at Hamilton College. It is the University's policy to keep radiation exposure as low as reasonably achievable (ALARA).

Adherence to the stated regulations, procedures, and protocols will ensure maximum radiation safety to those using radioactive materials. Failure to follow procedures in this manual may result in excessive personnel exposure and may put in jeopardy the authorization of Hamilton College to use radioactive materials.

All personnel using radiation sources are expected to be familiar with radiation safety requirements in this guide and to conduct their operations in accordance with them. The University is committed to a program which will minimize personnel exposure.

Chairman, Radiation Safety Committee
Hamilton College

B. ORGANIZATIONAL CHART

The administrative structure to supervise the possession of radiation sources and their use within the College is set forth in the chart below. For details concerning these relationships, consult Sections C, D, and E of this manual.

President
|
Dean of the Faculty
|
Radiation Safety Committee
|
Radiation Safety Officer
|
Authorized Users
|
Qualified User, Restricted User

C. RADIATION SAFETY COMMITTEE

1. General Description

The Radiation Safety Committee shall be a standing College Committee.

The Radiation Safety Committee (RSC) shall consist of at least five members. It is recommended that the committee be composed of at least three faculty from the Science Departments, the Radiation Safety Officer (RSO), and an administrative representative. All members of the Committee, including the Chairperson, shall be appointed by the authority of the President of Hamilton College. The Radiation Safety Officer and the administrative representative will be permanent members of the Committee and will not be eligible to serve as Chairperson of the Committee. Other members than those designated above may be added as deemed appropriate by the President.

The responsibility of the Radiation Safety Committee shall be to establish and administer the radiation safety program for all licensed users of ionizing radiation sources. The Committee will ensure that all individuals who work with or in the vicinity of radioactive material have sufficient training and experience to enable them to perform their duties safely and in accordance with established regulations and license conditions.

This Committee has been designated by the State of New York as the responsible agent of the College. The RSC shall meet as often as necessary to conduct its business, but not less than once each calendar quarter and upon call of the Chairperson. A quorum shall consist of at least one-half of the Committee's membership, including the Chairperson, RSO and administrative representative.

The Radiation Safety Committee is the final authority in all matters pertaining to radiation safety.

2. Duties and Functions

The duties and functions of the RSC are to:

a. Be familiar with all pertinent New York Health Department regulations (State Sanitary Code, Chapter I - Part 16) and the terms of the license.

b. Establish rules, regulations, and policies regarding College radiation safety and radiation producing equipment.

c. Ensure that the College's program to maintain individual and collective doses as low as reasonably achievable (ALARA) is properly maintained. This will be accomplished by the performance of a semi-annual review of occupational radiation exposure records of all personnel working with radioactive materials (if applicable).

d. Review and act upon all applications for possession and use of sources of ionizing radiation. This will include a review of the individual's training and experience in working with radioactive materials and their ability to perform duties in accordance with specified regulations and license conditions.

e. Prescribe special conditions that will be required during a proposed use of radioactive material such as requirements for bioassays, physical examinations of users, and/or special monitoring procedures.

f. Receive and review periodic reports from the Radiation Safety Officer.

g. Review the entire radiation safety program at least annually to determine that all activities are being conducted safely and in accordance with specified regulations and license conditions.

h. Review with the Radiation Safety Officer major instances of alleged infractions during the use of radionuclides or radiation, or of safety rules, and take necessary action to correct such infractions.

i. Maintain written records of all Committee meetings, actions, recommendations, and decisions.

j. Ensure the byproduct material license is amended, if required, prior to any change in facilities, equipment, personnel, policies and/or equipment.

3. **Responsibility of Chairperson**

It shall be the responsibility of the Chairperson to:

a. Report periodically the actions of the RSC to the President or his designate.

b. Call for meetings of the RSC.

c. Circulate minutes of the RSC meetings to other committees with responsibility in the area of radiation safety, and to establish coordination with other responsible radiation safety bodies.

d. Appoint sub-committees to deal with specific areas of radiation as necessary.

e. It is a prerogative of the Chairperson to vote in all Committee matters.

4. **Hamilton College Radiation Safety Committee:**

David A. Gapp, Radiation Safety Officer, Professor of Biology
Pearl Gapp, Chair RCS, Laboratory Coordinator in Biology
Patricia Ingalls, Director, Campus Safety
Brian Hansen, Director of Environmental Protection and Safety
David G. Bailey, Associate Professor of Geosciences
Brian Collett, Associate Professor of Physics
Camille Y. Jones, Assistant Professor of Chemistry

D. RADIATION SAFETY OFFICER

1. General Description

The Radiation Safety Officer (RSO) is that person, who is appointed by the authority of the President of the College, and who by reason of education, training, and experience, is qualified to advise others in the safe use of radiation. The primary mission of the RSO is to execute the policies established by the RSC and to ensure compliance with the State regulations. The RSO reports directly to the RSC for matters of radiation safety concern.

2. Radiation Safety Officer is Responsible For:

a. General surveillance over all activities involving radiation and radioactive material, including routine monitoring and special surveys of all areas in which radioactive material is used.

b. Determining compliance with rules and regulations, license conditions, and the conditions of project approval specified by the Radiation Safety Committee.

c. Monitoring and maintaining special ventilation filter systems (fume hoods) associated with the use and or storage of radioactive material.

d. Furnishing consulting services on all aspects of radiation protection to personnel at all levels of responsibility within the College or engaged in College activities.

e. Purchasing and transferring all radioactive materials in accordance with Sections S and T of this manual.

f. Receiving, delivering, and opening all shipments of radioactive material arriving at the institution and receiving, packaging, and shipping all radioactive material leaving the institution.

g. Distributing and processing personnel monitoring equipment; determining the need for and evaluation of bioassays; keeping personnel exposure and bioassay records; and notifying individuals and their supervisors of exposures approaching any limits and recommending appropriate remedial action.

h. Conducting training programs and otherwise instructing personnel in the proper procedures for the use of radioactive materials and other radiation sources prior to use, at periodic intervals (refresher training), and as required by changes in procedures, equipment, regulations, etc.

i. Supervising and coordinating the radioactive waste disposal program, including keeping waste storage and disposal records and monitoring effluents.

j. Storing all radioactive materials not in current use, including wastes.

k. Performing leak tests on all sealed sources.

l. Maintaining an inventory of all radionuclides at the institution and limiting the quantity of radionuclides at the institution to the amounts authorized by the license.

m. Maintaining other records not specifically designated above; for example, receipt, transfer, and survey records.

n. Investigating any and all accidents, spills, unplanned releases to the environment, and other abnormal occurrences regarding radiation or radioactive material.

o. Supervising decontamination in case of accident.

p. Coordinating and submitting licensing applications and amendments to the State of New York.

q. Screening grant applications for licensing feasibility, prior to submission of the grant application to the granting agency.

r. Maintaining a file of radiation-producing and -detecting equipment at Hamilton College.

3. **The Radiation Safety Officer will also perform certain functions for the RSC.**

   a. The RSO will serve as secretary of the RSC, and keep RSC records.

   b. The RSO will furnish reports to the RSC as follows:

      1) The annual report on the status of the radiation safety program within the College.

      2) A semi-annual report of inventory of radioactive materials at Hamilton College.

      3) A report at every quarterly meeting of the RSC of unusual or abnormal incidents involving radiation and radioactive material.

4. **The Radiation Safety Officer has the authority to terminate immediately a project, activity, or use of radiation or radioactive material that is found to be a threat to health or property.** This would include the closing of a laboratory or the confiscation of radioactive material if such actions would remove or prevent the recurrence of a threat to health or property. Such a termination action shall be reported in writing to the Chairperson of the RSC within 48 hours after such termination action has been taken.

E. Definitions of Users of Radioactive Materials and Radiation Machines

The Radiation Safety Committee is empowered to authorize the possession and use of radioactive materials and radiation machines. Two categories of users have been established for which an individual may apply. These are **"Authorized User"** and **"Qualified User"**. A further discussion of each of these categories including the particular responsibilities and authorizations follows.

A chain of responsibility regarding the safe use of radioactive material and radiation machines exists from individual users to the RSC. This chain is independent of other administrative lines of control within Hamilton College. However, the RSC recognizes the right of any administrative entity within Hamilton College to impose additional restrictions, qualifications, and regulations regarding the use of radioactive material, radiation, or equipment by persons under its control.

Responsibilities of radionuclide users are outlined in Section G, and the procedures an individual must follow to become a user are presented in Section F of this manual.

1. **Authorized User.** A person designated by the RSC as an "Authorized User" may use and possess radioactive materials and/or radiation machines as specified by the RSC. An Authorized User bears the responsibility for the proper storage of materials under his/her control and for their proper use under his/her direction. Only an Authorized User may initiate the purchase or transfer of radioactive materials, as described in Sections S and T of this manual.

   In general, Authorized Users should be permanent members of the Hamilton College faculty or staff and ideally would have a position that would allow them to administer naturally the use of the radioactive materials under their authorization. An Authorized User may sponsor the use of radioactive materials and radiation machines by Qualified Users and personally supervise the use by Restricted Users. Further discussion of these activities appears below.

2. **Qualified User.** The category of "Qualified User" has been established to allow qualified persons to use radioactive material or radiation machines under specific circumstances under the sponsorship of an Authorized User. The latter shall bear primary responsibility for the safe use of the material or equipment. However, in the handling of radioactive materials or radiation machines, the Qualified User category is intended for students or technical employees whose association with Hamilton College may not be permanent and whose backgrounds may not be extensive enough to warrant a broad authorization to use radioactive materials or radiation machines. Such persons, sponsored by and with the written permission of an Authorized User to whom they have demonstrated their competence, may be permitted to use radioactive material or radiation machines in a manner specified by his/her application to the Committee without direct supervision. A Qualified User may not supervise the use of radioactive materials or radiation machines by Restricted Users except as specifically authorized by the RSC in writing.

3. **Restricted User.** A "Restricted User" is one who **has not received** authorization by the RSC as either an Authorized or Qualified User. A Restricted User may not use radioactive materials or radiation machines, except under direct supervision of an Authorized User.

4. Visiting Faculty

a. Visiting Faculty who are Leave Replacements: The RSO will apply for Authorized User status for visiting faculty who plan to use radioactive materials in their teaching laboratories. This requires amendment to the Radioactive Materials License and must be initiated at least two months prior to their arrival on campus.

b. Visiting Researchers and Scholars-in-Residence:

1) Host faculty will apply for Qualified User status (at least one month in advance of a proposed visit) for any visiting researchers and Scholars-in-Residence working under their authorization.

2) Visiting researchers cannot apply for Authorized User status. They must work under a College Authorized User, preferably the faculty member hosting their visit.

3) Host facility will provide dosimetry monitoring, as necessary.

4) Visitors must be instructed on the policies and procedures for radioactive materials handling at the College.

5) Records of instruction and dosimetry will be maintained by the RSO.

6) Visitors may not bring new sources or material on campus without prior approval from the RSC. Transfers will be made as outlined in Section T of this manual.

5. Direct or Personal Supervision

a. Direct supervision requires that the operation in question has been planned by the Authorized User, and the Restricted Users have been told of any potential hazards and been instructed in procedures to be followed both in normal circumstances and in the event of an abnormality or accident.

b. When the operation involves unsealed sources of radioactive material, the Authorized User must remain in the room in which the nuclide use is underway.

c. When the operation involves a sealed source or sources in a setup which does not present dose rates at the accessible boundary of the setup exceeding 2.5 mrem/hr, the Authorized User need not remain in the room, but must be in the same general area of the building in which the radionuclide use is underway, and must be aware of the operation in progress.

F. APPLICATION PROCEDURES AND GENERAL CRITERIA FOR APPROVAL

1. Application for possession and use of sources of radiation, and for Authorized User or Qualified User Status, will be made on the appropriate forms.

2. The application procedure has been broken down into two parts to facilitate application and amendment, and to minimize paperwork. Conceptually, these two parts are a "user" application (Form RSO-1) and a "use" application (Form RSO-2). "Use" and "User" applications must be filed initially and whenever significant changes are made.

3. An application will be submitted to the RSO for preliminary review. The application will then be reviewed by each RSC member, signed, and returned to the Chairperson with the following comments: Approve, Disapprove, Request Meeting of RSC to Discuss, or Questions and Remarks. All questions must be resolved before final approval, and prior to procurement of sources of radiation. Between regularly scheduled meetings, review and approval will ordinarily be done by mail and telephone.

4. Applications will be approved if the RSC is satisfied that the applicant:

   a. possesses adequate facilities and equipment, appropriate for the proposed use, which will ensure the safety of workers and public, and prevent or minimize environmental damage;

   b. has established safe and effective operating, handling, and emergency procedures;

   c. has adequate training and experience to safely carry out the proposed use;

   d. will maintain radiation exposures to workers and the public "as low as reasonably achievable" (ALARA); and

   e. will conform to all applicable regulations and procedures, such as recordkeeping, established by State and local authorities regarding all other aspects of possession and use of ionizing radiation.

5. On approval by the RSC, the user will be assigned a user number by the RSO. This number will be recorded on the user application and a copy of the completed application form will be provided to the user to serve as his/her AUTHORIZATION.

G. INDIVIDUAL RESPONSIBILITY

1. All Users

Each individual at Hamilton College, regardless of category or authorization, who has any contact with radioactive materials or other radiation sources is responsible for:

a. Being familiar with the Hamilton College Radiation Safety Manual.

b. Keeping his/her exposure to radiation and that of those working under his/her supervision as low as reasonably achievable, and specifically below the maximum permissible exposure listed in NY State Sanitary Code, Chapter I, Part 16.6 and Section K of this manual. Concentrations of radioactive materials in laboratory air shall be maintained below levels requiring posting as an airborne radioactivity area.

c. Wearing the prescribed monitoring equipment such as film badges and pocket dosimeters in radiation areas. Personnel who work only with pure alpha emitters or only with pure beta emitters having a maximum energy of less than 0.2 MeV will not be required to wear film badges. Extremity monitoring may be required for those individuals as determined by the RSO.

d. Having precautionary personnel surveys made at frequent intervals with a suitable survey instrument, and for recording the results.

e. Limiting the use of radionuclides authorized to them to individuals working under his/her direct supervision and to the location specified on the authorization form.

f. Keeping current working records of the receipt and disposition of radionuclides in their possession including use in classrooms, research, waste disposal, transfer, storage, etc. These records will be audited by the Radiation Safety Officer.

g. Transferring radioactive materials only according to Section T of this manual.

h. Following safe procedures as outlined in Section H of this manual.

i. Assuring that smoking, eating, drinking, and the application of cosmetics are prohibited in areas in which unsealed radioactive materials are present.

j. Ensuring that female workers are given specific instruction about prenatal exposure risks to the developing embryo and fetus prior to work with radioactive materials and radiation sources.

2. **Authorized Users**

In addition to items listed above, Authorized Users are further responsible for:

a. Adequate planning. Before an experiment is performed, the User should determine the types and amounts of radiation or radioactive material to be used. This will generally give a good indication of the protection required. The procedure must be well outlined. In most cases, before the procedure is actually performed with radioactive materials, it should be rehearsed so as to preclude accidents or unexpected circumstances.

b. Being present when radionuclides are used under their supervision.

c. Instructing those persons for whom they are responsible in the use of safe techniques and in the application of approved radiation safety practice.

d. Furnishing the Radiation Safety Officer with information concerning individuals and activities in their areas, particularly additions to or deletions from their personnel rosters.

e. Contacting the RSO whenever changes in operational procedures which might lead to personnel exposure are anticipated.

f. Complying with the regulations governing the use of radioactive materials as established by the State of New York and the Radiation Safety Committee for:

1) Correct procedure for the procurement of radioactive materials by purchase or transfer.

2) Posting radiation areas and areas where radioactive materials are used or stored.

3) Accounting for the disposition and amounts of radioactive materials in their area. Inventories of nuclides must be completed and received by the RSO every calendar quarter.

4) Assuring that all radioactive waste materials are consigned to the Radiation Safety Officer for disposal.

g. Reporting any incident or unusual occurrence related to the radioactive material or radiation producing equipment under their supervision. See Section O, "EMERGENCY PROCEDURES".

h. Informing the Radiation Safety Committee promptly of any employment of minors (persons under age 18) in activities involving radiation and radioactivity, or of possible radiation exposure of minors. Minors may not work in or frequent any Radiation Area or High Radiation Area.

H. LABORATORY RULES AND PROCEDURES

The purpose of this section is to provide procedures that ensure a safe working environment for laboratory personnel, to ensure public safety, and to avoid contamination of equipment and facilities.

1. **In advance of any work, the Authorized User must:**

   a. Discuss with the employees the work to be done and the necessary safety precautions in accordance with NY State Sanitary Code, Chapter 1, Part 16.13;

   b. Outline in writing the procedure for each job (make the amount of detail commensurate with the hazard);

   c. Stock the laboratory with plastic or rubber gloves, lab coats, safety goggles, warning tags and labels, wipes, appropriate survey/counting instruments, forms for necessary records, poly bags and tape for waste disposal, absorbent paper, etc. The use of good procedures is greatly facilitated by having proper tools/supplies at hand;

   d. Make arrangements with the RSO for radioactive waste disposal; and

   e. Have available and use when appropriate, remote handling devices, automatic pipettes or dispensers, tongs, etc., for the manipulation and transfer of radioactive preparations.

2. **The Rules and Procedures listed below should be followed by all laboratory personnel.**

   a. High standards of cleanliness and good housekeeping must be maintained in all laboratories where radioactive material is present.

   b. A RESTRICTED AREA is any area to which access is controlled for purposes of protection of individuals from exposure to radiation and radioactive materials. In general, laboratories or rooms where radioactive materials are stored or used are considered Restricted Areas with the exceptions noted below.

   c. In order to prevent accidental ingestion of radioactive materials, eating, drinking, smoking, storage and preparation of food, and application of cosmetics are not permitted in Restricted Areas unless within a specially marked CLEAN AREA. Such a Clean Area adjacent to a Restricted Area must:

      1) Have prior approval by the Radiation Safety Officer.

      2) Have its boundaries clearly delineated.

      3) Be labeled to exclude the use or storage of radioactive materials.

      4) Be located so that radioactive materials will not be transported through the area to be used or stored elsewhere in the laboratory.

      5) Not be in a laboratory where there is any reasonable expectation of airborne radioactivity.

   Ordinarily a Clean Area will not be approved by the RSO if there is a reasonable alternative.

Food, drink, coffee cups, ash trays, etc. found in Restricted Areas may be confiscated by the RSO. Specifically, food and drink must not be stored in refrigerators or cold rooms which are located in Restricted Areas or which are used for the storage of radioactive materials.

The above prohibitions do not apply to Restricted Areas in which the only radioactive materials are in the form of encapsulated Sealed Sources. The category of "Sealed Sources" does not include "unopened stock vials".

d. **NOTE: The only designated "hot sink" for cleaning of contaminated glassware and disposal of aqueous radioactive material is located in the hot-lab (Science Building Room 219b).** This sink should be labeled and the drain tagged to warn personnel prior to any repair work being performed. Repair and construction personnel who must work in Restricted Areas shall be instructed in the health and safety aspects of radiation on their job. Such instruction shall be provided by the Authorized or Qualified User or, at the Authorized User's request, by the RSO.

e. Designate and label a **storage area** for radionuclides. Keep them there when not in immediate use.

f. Radioactive materials shall be used and stored in such a manner as to restrict unauthorized persons from using or removing such materials. Restricted Areas shall be kept locked when not attended by qualified personnel.

g. Measure and record the photon radiation levels (in mR/hr) in the work and storage area and adjacent non-controlled areas, with an appropriately calibrated detector. A GM or scintillation probe may be useful to detect "hot spots" even if not calibrated for that particular energy. Provide sufficient shielding to keep radiation exposures as low as reasonably achievable and always below established limits. Consult the Radiation Safety Officer for help in designing shielding and minimizing expense.

h. Designate and label the radioactive work area(s). Consider the consequences of leakage or equipment failure. Use stainless steel or plastic trays to help confine liquids if spilled.

i. As with any laboratory research activity, all individuals **must** wear safety glasses when working with loose radioactive materials.

j. When working with radioactive materials, wear a lab coat, and plastic or rubber gloves for protection of clothes and skin. To avoid spread of contamination, remove gloves at work area. Change gloves frequently to prevent spread of contamination. Do not handle faucets, light switches, door knobs, telephones, etc. with potentially contaminated gloves. Special protection may be required for open cuts or wounds.

k. Respirators are not an approved method of protection from airborne radioactive materials. Experiments and equipment shall be designed so that respirators are not needed. Confine work with gaseous, volatile or dust-forming radioactive material to hoods or glove boxes as appropriate.

l. Confine radioactive solutions in covered containers plainly identified and with name of compound, radionuclide, date, activity, and radiation level if applicable. Labels shall conform with standards in Section N of this manual and in NY State Sanitary Code, Chapter I, Part 16.12.

m. Never pipette radioactive solutions by mouth. Mechanical devices must be used. Push-button pipettors with disposable tips are strongly recommended. Segregate pipetting devices used with radioactive materials from those used with non-radioactive solutions.

n. Persons who are designated to wear personnel monitoring equipment (film badges, TLDs, pocket dosimeters, etc.) by the Radiation Safety Officer should wear such devices at all times when they work with or near radioactive materials for which the devices are appropriate. Placement of monitoring devices will be as outlined in Section M of this manual.

o. Supply containers for radioactive waste and contaminated glassware at the work location. Avoid transporting contaminated articles from the work area through clean lab areas. Shield the waste containers as required to prevent unnecessary exposure. Waste containers should be secured and adequately labeled to prevent accidental disposal by housekeeping personnel.

p. If working with millicurie quantities of gamma or hard beta emitters (>1 MeV), check hands, feet and clothing with end window GM meter or other appropriate instrument for contamination after handling radioactive materials. The immediate work area should be checked for contamination **at least** at the end of each working day.

q. Never perform extensive radiochemical work with significant levels of radioactive material (>1 mCi) until the procedure has been tested by a "dry run" to preclude unexpected complications.

r. In case of spill or other accident, alert nearby personnel, confine spill, block off and mark area, decontaminate, and monitor before moving temporary signs or barricade. If personnel contamination is involved, remove contaminated outer clothing, wash skin, and monitor; seek medical advice if contamination persists and/or if injury has occurred. Report all accidents and injuries to the Radiation Safety Officer (RSO). See Section O, "EMERGENCY PROCEDURES," in this manual.

s. The individual responsible for a spill is responsible for decontamination. Do not use custodial personnel unless specifically assigned the task by the RSO and the Authorized User.

t. All equipment which is suspected to have come in contact with loose radioactive material shall be considered potentially contaminated and shall be monitored for contamination by Radiation Safety personnel before being removed from the laboratory for repair, modification, calibration, storage, or use elsewhere.

u. Custodial personnel shall clean only areas designated by the Authorized User. The users or their qualified laboratory personnel shall be responsible for the rest of the housecleaning. The Authorized User is responsible to ensure that housekeeping personnel do not come in contact with radioactive contamination.

v. When use or storage of radioactive material in a facility is terminated, the RSO is to be notified. The RSO will perform a termination survey before releasing the area for other uses.

I. RADIATION MONITORING AND CONTROL

1. Surveys

a. Radiological surveys of areas where radioactive materials are used, stored, or released are an essential part of any radiation safety program. **It is the responsibility of the Authorized User or his/her designee to conduct and record the required surveys as described below.** Records of such surveys are required by law, and will be examined in each Authorized User's work area during State inspections and inspections by the RSO. Records must be signed and dated. Survey records are the property of the licensee, not the individual user, and shall be retained as required by NY State Sanitary Code, Chapter I, Part 16.14.

b. A complete survey includes monitoring for fixed and removable contamination, and exposure rate measurements.

1) Fixed radioactive contamination can only be detected by a survey instrument appropriate to detect the type, energy and quality of radiation present. Fixed tritium contamination is very difficult to detect; however, most other common tracers can be detected with a thin end window GM instrument.

2) Removable radioactive contamination is generally a more serious problem. It can be detected by wipe tests (also called smears or swipes). Wipe surveys are performed by wiping the surface to be evaluated with a small piece of filter paper or cotton swab. A surface of approximately 100 cm^2 (4x4 in^2) should be wiped, and the paper or swab should be counted in an appropriately calibrated liquid scintillation counter or a gamma scintillation counter.

3) Exposure rate or absorbed dose rate measurements must be made and recorded in areas where they are significant. This excludes soft-beta emitters, such as H-3, C-14, and S-35, but includes P-32, and, of course, any gamma emitters. Geiger-Mueller (GM) counters are only good for exposure rate measurements if they have been calibrated at the energy in question. GMs are best used for the detection of small amounts of activity. A thin sodium iodide detector is excellent for Iodine-125.

4) Monthly radiation surveys shall be performed in laboratories using gamma (photon) emitting sources, other than exempt reference standards. Radiation surveys shall also be performed after the acquisition of additional radioactive material, or after any change has been made in shielding.

5) Hazard evaluations will be made periodically by the RSO, but all radiation workers must be alert for radiological and other hazards in the laboratory.

c. Other kinds of surveys include air and water sampling as deemed necessary by the RSO.

d. Areas should be surveyed at reasonable intervals, depending on the amount and type of radioactive material used, and the nature and frequency of work. "Reasonable intervals" will be deemed to be at least monthly in areas where radioactive materials were used. The immediate areas (e.g., hoods, bench tops) in which radioactive materials are being used

should be checked for contamination at least once daily by the radiation workers in the laboratory. More extensive surveys shall be performed at the completion of an experiment or if contamination is suspected. Such surveys are required to be documented, even if no contamination is found.

e. Below are some examples of areas that should be surveyed:

- benches, tables and counter tops
- apparatus
- storage areas
- fraction collectors
- refrigerators and freezers
- waste storage areas
- cold rooms
- sinks
- balances
- centrifuges
- stirrers
- floor
- fume hoods
- counting rooms
- drawers where hot equipment is kept

f. Equipment and/or areas found with removable contamination must be decontaminated to reduce the radioactive contamination ALARA but not to exceed the limits specified in Table I-1. Exposure rates must be kept ALARA, and anything over 1.0 mR/hr should be reported to the RSO.

g. It is imperative that every survey performed is properly documented. Surveys are a legal record and should be done neatly and accurately in a black ball point pen. The survey document should include a floor plan of the area surveyed and include the following information.

1) Location of the survey

2) Purpose of the survey (routine, post-spill, etc.)

3) Date and time the survey was performed

4) Make, model, and serial number of each instrument used for measuring direct radiation and/or for counting wipes

5) Efficiency of counting instruments

6) Calibration due date for each instrument (this date must be *after* the date of the survey)

7) Surveyor's name and signature

h. Copies of survey documents shall be maintained by the Authorized User's. The Authorized User will submit a copy of Form RSO-3 monthly to the RSO indicating the performance of the required radiological survey or that radioactive materials were not used in the area for the month.

i. The RSO will conduct an annual survey/assessment of each laboratory authorized to use radioactive materials. This survey will include radiation and contamination surveys and evaluation of radiation safety practices employed by the Authorized Users, such as proper signs and labels, posting of notices to employees, control of radioactive material, shielding materials, and waste disposal. Reports of the surveys shall be sent to the Authorized User with recommended corrective actions as appropriate.

2. **Acceptable Limits of Contamination**

Areas should be maintained essentially free of removable contamination but in any case contamination shall not exceed the values listed in the Tables I-1.

TABLE I-1

RADIOACTIVE SURFACE CONTAMINATION LIMITS

APPLICATION	ALPHA (dpm/100 cm^2)		BETA/GAMMA[1]	
	Total	Removable	Total (mR/h)	Removable (dpm/100cm^2)
Controlled Area				
Basic Guide	25,000 (Max.) 500 (Ave.)	500	1.0	5,000
Clean Area	1,000	100	0.5	1,000
Non-Controlled Area				
Skin, Personal clothing	500	N.D.[2]	0.1	N.D.[2]
Release of Materials or Facilities	2,500 (Max.) 500 (Ave.)	100	0.2	1,000

[1] Measured at 1 cm from the surface

[2] N.D. Non-detectable

3. **Dose Equivalent Rate Limits**

Dose equivalent rates above the levels stated below will be considered excessive unless they are of short duration, or, in the case of restricted areas, unless other steps are taken to limit personnel exposure. Barring these exceptions, action must be taken to reduce the dose equivalent rates as far as reasonably achievable below the levels listed in Table I-2.

TABLE I-2

DOSE EQUIVALENT GUIDELINE VALUES

Area	Action Level
Restricted	2.5 mrem/hour
Unrestricted	0.2 mrem/hour

4. **Survey Instruments**

Authorized Users will be required by the RSC to have immediate access to suitable survey instruments such as Geiger-Mueller detectors. Such instruments will be maintained and calibrated as stated in Section J of this manual.

5. In the event that the spread of radioactive contamination is suspected, all work in the area shall be halted immediately. The RSO shall be contacted as soon as possible. See Section O, "Emergency Procedures", of this manual.

J. INSTRUMENT CALIBRATIONS

Radiation detection instrumentation requires periodic checking and calibration. Radiation detection instrumentation is required to be calibrated at least once annually and after repairs by a licensed organization such as:

RSA Laboratories, Inc. 19 Pendleton Drive PO Box 61 Hebron, CT 06248	Harshaw/Bicron 6801 Cochran Road Solon, Ohio 44139	Ludlum Instruments, Inc. P. O. Box 810 501 Oak Street Sweetwater, Texas 79556
NRC License No. 06-30007-01	NRC License No. 34-13845-01	State of Texas Calibration License No. LO-1963

or another company specifically licensed by the U.S. NRC or an Agreement State to perform such services.

Prior to using any portable instrument to perform a radiological survey the user will perform the following checks.

1. Check the physical condition of the meter. Look for damage, and listen for apparent loose internal components. Check the cable for a good connection, and report any deficiencies to the RSO.

2. Ensure that the instrument has been calibrated within the last year.

3. Check battery/power supply.

4. Perform a source check. Put the selector switch on one of the operating positions, then expose the detector to a check source and ensure that the detector responds properly to radiation. Check the instrument again after use to ensure that it didn't fail during use.

K. IONIZING RADIATION DOSE LIMITS

1. Dose Limits

a. No person shall be permitted to receive an annual dose in excess of that listed in Table K-1 below.

Table K-1

DOSE LIMITS

Exposure Category	Annual Dose Limit (rem)
Total effective dose equivalent	**5**
Lens of eyes	**15**
Extremities	**50**
Skin	**50**
Committed dose equivalent (organs)	**50**

b. In no case shall an individual under the age of 18 years be permitted to receive a radiation dose in excess of 10 percent of the limits set forth in table K-1.

c. No individual shall be exposed to airborne radioactive material in concentrations:

1) In excess of the derived air concentrations (DACs) specified in Appendix 16-C, Table 1, Column 3 to the NY State Sanitary Code Chapter I, or

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

d. The dose to an embryo/fetus during the entire pregnancy, due to occupational exposure of a **declared pregnant woman** *, shall not be allowed to exceed 0.5 rem.

** A **declared pregnant woman** is a woman who has voluntarily informed her employer, in writing, of her pregnancy and the estimated date of conception.*

L. ALARA PROGRAM

1. Commitment

a. Hamilton College is committed to the program described herein for keeping individual and collective doses as low as is reasonably achievable (ALARA). In accordance with this commitment, we hereby describe an administrative organization for radiation safety and will develop the necessary written policy, procedures, and instructions to foster the ALARA concept within our institution. The organization will include a Radiation Safety Committee (RSC) and a Radiation Safety Officer (RSO).

b. We will perform a formal annual review of the radiation safety program, including ALARA considerations. This will include reviews of operating procedures and past dose records, previous inspection reports, etc., and consultations with the radiation safety staff or outside consultants.

c. Modifications to operating and maintenance procedures and to equipment and facilities will be made if they will reduce exposures unless the cost, in our judgment, is considered to be unjustified. We will be able to demonstrate, if necessary, that improvements have been sought, that modifications have been considered, and that they have been implemented when reasonable. If modifications have been recommended but not implemented, we will be prepared to describe the reasons for not implementing them.

d. In addition to maintaining doses to individuals as far below the regulatory limits as is reasonably achievable, the sum of the doses received by all exposed individuals will also be maintained at the lowest practicable level. It would not be desirable, for example, to hold the highest doses to individuals to some fraction of the applicable limit if this involved exposing additional people and significantly increasing the sum of radiation doses received by all involved individuals.

2. Radiation Safety Committee

a. Review of Proposed Users and Uses

1) The RSC will thoroughly review the qualifications of each applicant with respect to the types and quantities of materials and methods of use for which application has been made to ensure that the applicant will be able to take appropriate measures to maintain exposure ALARA.

2) When considering a new use of byproduct material, the RSC will review the efforts of the applicant to maintain exposure ALARA.

3) The RSC will ensure that the users justify their procedures and that individual and collective doses will be ALARA.

b. Delegation of Authority

(The judicious delegation of RSC authority is essential to the enforcement of an ALARA program.)

1) The RSC will delegate authority to the RSO for enforcement of the ALARA concept.

2) The RSC will support the RSO when it is necessary for the RSO to assert authority. If the RSC has overruled the RSO, it will record the basis for its action in the minutes of the quarterly meeting.

c. Review of ALARA Program

1) The RSC will encourage all users to review current procedures and develop new procedures as appropriate to implement the ALARA concept.

2) The RSC will perform a quarterly review of occupational radiation exposure with particular attention to instances in which the investigational levels in Table L-1 are exceeded. The principal purpose of this review is to assess trends in occupational exposure as an index of the ALARA program quality and to decide if action is warranted when investigational levels are exceeded. (See Section 6 below for a discussion of investigational levels.)

Table L-1

Investigational Levels
(mrems per calendar quarter)

Exposure Category	Level I	Level II
Total effective dose equivalent	60	125
Lens of eyes	185	375
Extremities	625	1,250
Skin	625	1,250

3) The RSC will ensure an evaluation of the institution's overall efforts for maintaining doses ALARA is performed on an annual basis. This review will include the efforts of the RSO, authorized users, and workers as well as those of management.

3. Radiation Safety Officer

a. Annual and Quarterly Review

1) Annual review of the radiation safety program. The RSO will perform an annual review of the radiation safety program for adherence to ALARA concepts. Reviews of specific methods of use may be conducted on a more frequent basis.

2) Quarterly review of occupational exposures. The RSO will review at least quarterly the external radiation doses of authorized users and workers to determine that their doses are ALARA in accordance with the provisions of Section 6 of this program, and will prepare a summary report for the RSC.

3) Quarterly review of records of radiation surveys. The RSO will review radiation surveys performed in unrestricted and restricted areas to determine that dose rates and amounts of contamination were at ALARA levels during the previous quarter, and will prepare a summary report for the RSC.

b. Education Responsibilities for ALARA Program

The RSO will ensure that authorized users, workers, and ancillary personnel who may be exposed to radiation will be instructed in the ALARA philosophy and informed that the Administration, the RSC, and the RSO are committed to implementing the ALARA concept.

c. Cooperative Efforts for Development of ALARA Procedures

Radiation workers will be given opportunities to participate in formulating the procedures that they will be required to follow.

1) The RSO will be in close contact with all users and workers in order to develop ALARA procedures for working with radioactive materials.

2) The RSO will receive and evaluate the suggestions of individual workers for improving health physics practices and will encourage the submittal of these suggestions.

d. Reviewing Instances of Deviation from Good ALARA Practices

The RSO will investigate all known instances of deviation from good ALARA practices and, if possible, will determine the causes. When the cause is known, the RSO will, if required, implement changes in the program to maintain doses ALARA.

4. **Authorized Users**

a. New Methods of Use Involving Potential Radiation Doses

1) The Authorized User will consult with the RSO and/or RSC during the planning stage before implementing new uses for radioactive materials.

2) The Authorized User will review each planned use of radioactive materials to ensure that doses will be kept ALARA. Trial runs may be helpful.

b. Authorized User's Responsibility to Supervised Individuals

1) The Authorized User will explain the ALARA concept and the need to maintain exposures ALARA to all supervised individuals.

2) The Authorized User will ensure that supervised individuals who are subject to occupational radiation exposure are trained and educated in good health physics practices and in maintaining exposures ALARA.

5. **Individuals Who Receive Occupational Radiation Doses**

a. Workers will be instructed in the ALARA concept and its relationship to work procedures and work conditions.

b. Workers will be instructed in the recourse that is available if they feel that ALARA is not being promoted on the job.

6. **Establishment of Investigational Levels in Order to Monitor Individual Occupational External Radiation Doses**

Hamilton College hereby establishes investigational levels for occupational external radiation doses which, when exceeded, will initiate review or investigation by the RSC and/or the RSO. The investigational levels that we have adopted are listed in table L-1. These levels apply to the exposure of individual workers.

The RSO will review and record on Form NRC-5, "Current Occupational External Radiation Exposures," or an equivalent form (e.g., dosimeter processor's report) results of personnel monitoring not less than once in any calendar quarter. The following actions will be taken at the investigational levels as stated in Table L-1:

a. Personnel dose less than Investigational Level I.

Except when deemed appropriate by the RSO, no further action will be taken in those cases where an individual's dose is less than table L-1 values for the Investigational Level I.

b. Personnel dose equal to or greater than Investigational Level I but less than Investigational Level II.

The RSO will review the dose of each individual who's quarterly dose equals or exceeds Investigational Level I and will report the results of the reviews at the first RSC meeting following the quarter when the dose was recorded. If the dose does not equal or exceed Investigational Level II, no action related specifically to the exposure is required unless deemed appropriate by the Committee. The Committee will, however, review each such dose in comparison with those of others performing similar tasks as an index of ALARA program quality and will record the review in the Committee minutes.

c. Personnel dose equal to or greater than Investigational Level II.

The RSO will investigate in a timely manner the causes of all personnel doses equaling or exceeding Investigational Level II and, if warranted, will take action. A report of the investigation, any actions taken, and a copy of the individual's Form NRC-5 or its equivalent will be presented to the RSC at its first meeting following completion of the investigation. The details of these reports will be included in the RSC minutes.

d. Reestablishment of investigational levels to levels greater than those listed in table L-1.

In cases where a worker's or a group of workers' doses need to exceed an investigational level, a new, higher investigational level may be established for that individual or group on the basis that it is consistent with good ALARA practices. Justification for new investigational levels will be documented.

M. PERSONNEL MONITORING AND BIOASSAY PROCEDURES

1. External Monitoring

a. All persons who enter an area under such conditions that they may receive a radiation exposure greater than 10 percent of the limits set forth in Section K of this manual shall wear appropriate personnel monitoring devices. (Badges are not required for H-3, C-14 and S-35 work.) These monitoring devices shall be film badges or thermoluminescent dosimeters (TLDs) unless other devices are authorized by the Radiation Safety Officer.

b. The RSO shall supervise the obtaining, distribution, and collection of personnel monitoring devices.

c. Dosimetry used to measure whole body exposure shall be worn on the upper chest area with open window facing away from the body. Ring badges shall be worn under protective gloves with the TLD chip facing the radioactive material.

d. When film badges are used, the film shall be changed on a monthly basis or more frequently as determined by the RSO.

e. When a TLD is used the badge will be processed as follows:

1) Monthly (or more frequently as determined by the RSO) where significant exposures are possible.

2) Quarterly where exposures are expected to be low.

f. Pocket dosimeters shall be worn in addition to film badge or TLD when indeterminate levels of radiation are suspected or as determined by the RSO.

g. If an exposure in excess of the specified limits is suspected, the RSO shall be notified immediately so that the monitoring device may be processed for rapid analysis.

h. It is the responsibility of the Authorized User to notify the RSO whenever an individual will require personnel monitoring and whenever the need for personnel monitoring is terminated. The RSO will make the final determination on who is issued personnel dosimeters.

i. When not in use, personnel monitoring devices shall be stored in an area with low background radiation levels. Personnel monitoring devices shall not be taken home.

j. AT NO TIME WILL A PERSONNEL MONITORING BADGE BE DELIBERATELY EXPOSED TO RADIATION UNLESS IT IS WORN BY THE EXPERIMENTER OR UNLESS THE RSO APPROVES. The badge shall not be worn during non-occupational exposure such as a medical x-ray.

k. All personnel monitoring records shall be maintained by the RSO.

2. Bioassay Procedures

a. Hydrogen-3 (Tritium). Persons involved in operations using H-3 in amounts greater than ten (10) millicuries per week, shall have bioassays performed:

1) within one week following single operations;

2) at weekly intervals for continuing operations;

3) on request; or

4) whenever deemed necessary by the RSO.

Bioassays need not be performed if:

1) the tritium is in the form of sealed sources and metallic foils; or,

2) the tritium is in a gaseous form ($^{3}H_{2}$) and the weekly quantity being used is less than 100 mCi.

Bioassays will consist of urinalysis by liquid scintillation counting, and will be performed by the RSO. Aliquot's of urine will be counted in a liquid scintillation counter, along with blanks and standards. Sensitivity of this assay will be greater than 0.5 μCi/liter. Quench correction will be done using external standardization, with internal standardization (the addition to the sample vial of a known activity of $^{3}H_{2}O$) used to quantify samples with activity greater than 0.5 μCi/liter.

b. Iodine-125. All individuals involved in the use of I-125 in amounts greater than one (1) millicurie, in a single operation or within one week, shall have thyroid counts performed within 72 hours of such use, provided that the use is such that there could be significant release of the radioiodine to the air as gas, e.g., an oxidative iodination process.

If the thyroid burden exceeds 0.12 μCi of Iodine-125, immediate action will be initiated to determine the cause of exposure and a repeat measurement will be performed within two weeks. Investigators proposing use of radioiodine that is bound to nonvolatile compounds in quantities less than 1 mCi during a quarter will not require routine bioassay. This applies to radioimmunoassay (RIA) kits containing I-125 or I-131 that is bound to a nonvolatile carrier.

Thyroid counts will be performed by the RSO or an individual approved by the RSO. Thyroid counting apparatus will consist of a NaI (Tl) crystal with appropriate electronics, and will have a minimum sensitivity of 50 nCi for any of the radioiodines *in vivo*. The apparatus will be calibrated using a standard neck phantom and an appropriate source (e.g., I-129, simulated I-125).
c. Other bioassays will be required at the discretion of the Radiation Safety Officer.

d. Bioassay records will be maintained in accordance with NY State Sanitary Code Chapter I, Part 16.14.

N. MARKING AND LABELING

Rooms, areas, and equipment where radioactive materials are used or stored shall be clearly marked with appropriately worded and designated standard radiation signs, as required by NY State Sanitary Code Chapter I, Part 16.12.

1. Each area or room where licensed materials are used or stored in quantities exceeding 10 times the quantity of such material specified in Appendix 16-A, Table 9 of the NY State Sanitary Code Chapter I, shall be conspicuously posted with a sign or signs bearing the radiation symbol and the words "CAUTION RADIOACTIVE MATERIAL(S)" or "DANGER RADIOACTIVE MATERIAL(S)." The exception to this rule is the case where:

   a) The radioactive material is in an area or room which is subject to the licensee's control for less than 8 hours and during this time it is constantly attended by a person who takes the precautions necessary to prevent the exposure of individuals from exceeding the established dose limits.

2. Each container in which licensed radioactive material is used, stored, or transported shall be labeled with the radiation symbol, the words "CAUTION RADIOACTIVE MATERIAL," and the radionuclide, quantity, and date of measurement. Exceptions to this rule are in cases where:

   a) The concentration of the material in the container does not exceed the limits specified in Appendix 16-A, Table 3 to NY State Sanitary Code Chapter I.

   b) The quantity of the material in the container does not exceed the limits specified in Appendix 16-A, Table 9 to NY State Sanitary Code Chapter I.

   c) The containers are used transiently in lab work with the user present.

   d) Containers are packaged and labeled in accordance with USDOT regulations.

3. Any area, accessible to individuals, in which radiation levels could result in an individual receiving a dose equivalent in excess of 5 mrem in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates, is defined as a **RADIATION AREA.** Each such area shall be posted with a conspicuous sign or signs bearing the radiation symbol and the words "CAUTION RADIATION AREA."

4. Any area, accessible to individuals, in which radiation levels could result in an individual receiving a dose equivalent in excess of 100 mrem in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates, is defined as a **HIGH RADIATION AREA.** Each such area shall be posted with a conspicuous sign or signs bearing the radiation symbol and the words "CAUTION HIGH RADIATION AREA" or "DANGER HIGH RADIATION AREA."

5. An **AIRBORNE RADIOACTIVITY AREA** is defined as a room, enclosure, or area in which airborne radioactive materials, composed wholly or partly of licensed material, exist in concentrations -

   a. In excess of the derived air concentrations (DACs) specified in Appendix 16-C, Table 1, Column 3 to the NY State Sanitary Code Chapter I, or

   b. To such a degree that an individual present in the area without respiratory protective

equipment could exceed, during the hours an individual is present in a week, an intake of 0.6 percent of the annual limit on intake (ALI) or 12 DAC hours.

c. Any area which falls under the scope of this definition shall be posted with a conspicuous sign or signs bearing the radiation symbol and the words "CAUTION AIRBORNE RADIOACTIVITY AREA" or "DANGER AIRBORNE RADIOACTIVITY AREA."

6. Radiation labels must be defaced or removed from discarded containers and packaging which are disposed of as non-radioactive waste. After closeout surveys, radiation signs and labels must be removed from rooms or areas which were formerly used for radioactive work. Labels and markings should be promptly removed from apparatus which has been checked for contamination and is no longer to be used with radioactive materials. Don't abuse radiation markings and labels. Use them sparingly, and only where needed.

O. EMERGENCY PROCEDURES

1. Principles

Incidents involving the spillage or release of radioactive materials include a wide range of possibilities, ranging from minor to very serious, possibly involving injuries, radiation exposure to personnel, contamination of personnel, fire or explosion, and theft. Emergency procedures cannot cover all possibilities, so there are a few guiding principles to keep in mind:

a. Human health and safety is paramount. Radiation exposure must be minimized; however, it is possible that other injuries may be more critical in determining the course of action.

b. Containment of the radioactive materials or radiation source involved is important to reduce and prevent further exposure, and to minimize costly cleanup.

c. Notification of emergency personnel such as Security, Fire Department, Medical Personnel, and Radiation Safety personnel.

d. Protection of property from fire, explosion, or other damage must also be considered.

e. Legal requirements of reporting and recordkeeping after the incident must be met.

f. Determine the level of the emergency, i.e., major or minor spill, by using the following Table. Spills at or above these microcurie amounts are considered major, below are considered minor.

Radionuclide	Microcuries	Radionuclide	Microcuries
H-3	1,000	C-14	1,000
P-32	10.0	Na-22	10.0
S-35	1,000	I-125	1.0
U-238	0.01		

Bearing these principles in mind, the following emergency action guidelines are issued.

2. Minor Spills of Liquids and Solids

a. Notify persons in the area that a spill has occurred.

b. Prevent the spread of contamination by covering the spill with absorbent paper. If the spill consists of small amounts of a radionuclide bound in a volatile compound, i.e., I-125 or H-3, dilute spilled material with an alkaline radioactivity decontaminant, such as Count-Off, and then absorb the liquid with absorbent paper.

c. Clean up the spill using disposable waterproof gloves and absorbent paper. Carefully fold the absorbent paper with the clean side out and place in a poly bag for transfer to a radioactive waste container. Also put contaminated gloves and any other contaminated disposable material in the bag.

d. Survey the area with a low-range radiation detector survey meter. Check the area around the spill. Also check your hands, clothing, and shoes for contamination

e. Report the incident to the Radiation Safety Officer (RSO).

3. **Major Spills of Liquids and Solids**

a. Clear the area. Notify all persons not involved in the spill to vacate the room and monitor themselves.

b. Prevent the spread of contamination by covering the spill with absorbent paper, but do not attempt to clean it up. To prevent the spread of contamination, limit the movement of all personnel who may be contaminated.

c. Shield the source if possible. This should be done only if it can be done without further contamination or a significant increase in radiation exposure.

d. Close the room and lock or otherwise secure the area to prevent entry.

e. Notify the Radiation Safety Officer. Inform the RSO of the nature of injuries, if any; the radionuclide identity and activity involved; and any other pertinent information.

4. **Accidents Involving Airborne Radioactivity**

a. Notify all other persons to vacate the room immediately.

b. Close all windows, escape valves, and switch off ventilation.

c. Vacate the room.

d. If there is radioactive contamination on the skin, flush thoroughly with luke-warm water. If the contamination is on clothing, discard outer clothing at once. Use emergency shower if necessary. If there are injuries, see Injuries, below. See Decontamination of Personnel, below.

e. Notify the Radiation Safety Officer. Inform the RSO of the nature of injuries, if any; the radionuclide identity and activity involved; and any other pertinent information.

f. Ascertain that all doors giving access to the room are closed and locked. If necessary, post guards to prevent accidental opening of doors.

g. Radiation Safety personnel will monitor all persons involved for bodily contamination and will direct cleanup and decontamination.

h. Permit no one to enter or leave the area until Radiation Safety approval is obtained.

5. **Injuries to Personnel Involving Contamination**

a. Make every effort possible to rescue injured and trapped persons and remove them from the incident area.

b. Call Security. They will call for Emergency Medical Aid and the RSO.

c. First aid should be provided to those persons where it is necessary to save life or minimize injury.

d. Wash minor wounds immediately under warm running water for a minimum of 15 minutes if possible.

e. Remove and save all articles of contaminated clothing, jewelry, etc.

f. Permit no person involved in a radiation injury to return to work or leave the premises without approval of Radiation Safety personnel or a physician.

g. When it is necessary to send an individual to a hospital or other medical facility before Radiation Safety Personnel or a physician knowledgeable in radiological health arrives, inform ambulance personnel who will be in contact with any injured individual, of the possibility of radioactive contamination. Also, inform the hospital or medical facility that the individual may be contaminated with radioactive material.

6. **Fire or Explosions Involving Radioactivity**

a. Notify all persons in the room and building at once. Call Security.

b. If radiation hazard is not immediately present, attempt to extinguish fire with an appropriate type fire extinguisher.

c. Fire or explosion may result in airborne radioactivity. Keep upwind and avoid smoke, fumes, and dust.

d. Treat injuries and spills as above. Decontaminate personnel as specified below.

e. Restrict access to the incident area and prevent unnecessary handling of incident debris. Permit no one to leave except for medical treatment, and get the names and addresses of persons removed.

7. **Decontamination of Personnel**

a. Measures to be taken in case of internal contamination.

Radioactive contamination of personnel can be internalized through ingestion, inhalation, wounds or skin penetration. If anyone suspects internal contamination in case of an accident during work, it should be immediately reported to the Radiation Safety Officer.

Internal contamination is essentially a medical problem, parallel in some ways to the absorption of chemical toxins. Special corrective procedures should, therefore, combine with normal medical practice under medical advice and supervision.

Aims of the corrective procedures are: (a) try to eliminate as much of the internally introduced contaminant still remaining in the mouth, gastro-intestinal or respiratory tract, as quickly as possible and try to prevent or reduce its uptake into the bloodstream and tissues; (b) try to prevent fixation of the contaminant in the body or try to increase its excretion from the body.

For the first of these aims it is sometimes necessary that the contaminated person or another non-medical person take immediate action (in the first seconds or minutes) for instance, to

promote the mechanical elimination of the contaminant by vomiting or expectoration.

In case of contaminated small open wounds, cuts, punctures, or other injuries, the wound should be immediately washed and bleeding encouraged if necessary, and the individual referred to a physician.

For the second of the aims indicated above, any further procedure of internal decontamination (e.g., more complicated chemical or physicochemical methods) is a matter of medical treatment. It should be undertaken as soon as possible but only under medical supervision by trained medical professionals.

b. Measures to be taken in case of external contamination

External contamination on the person can be a hazard in three ways:

1) It may cause injury from local exposure of the skin.

2) It may penetrate the intact skin (especially in the presence of certain organic solvents).

3) It may eventually be transferred into the body by ingestion or inhalation.

The danger of loose activity being eventually carried into the body is by far the most critical hazard, so that decontamination procedures are primarily concerned with loose contamination.

As a rule, except for decontamination of hands, or except in cases of emergency as agreed upon by the Radiation Safety Officer, all mild decontaminating procedures described in the two paragraphs below should be carried out under supervision of the Radiation Safety Officer. Attempts to remove contamination which resists mild procedures should only be made under medical supervision.

The immediate washing of contaminated areas with water and soap is the method of choice for removing loose contamination, subject to certain elementary precautions:

1) Tepid water, not too hot, should be used;

2) Soap should not be abrasive or highly alkaline;

3) Washing can be helped by scrubbing with a soft brush only and in such a way as not to abrade the skin;

4) The skin should be washed for a few minutes at a time, then blotted dry and monitored.

Washing could be repeated if necessary (as indicated by monitoring) provided there is no indication of the skin becoming damaged.

If this procedure fails, only mild detergent approved by the Radiation Safety Officer might be used, although repeated applications of detergents to the same area of the skin, hands for instance, might injure the skin and allow the contamination to penetrate.

Use of organic solvents or of acid or alkaline solutions should be avoided.

Special attention should be paid to proper decontamination of creases and folds in the skin, hair and of such parts of the hands as finger nails, inter-finger space and the outer edges of the hands.

Care should be taken to avoid as much as possible the spreading of the contamination to uncontaminated parts of the body and to avoid internal contamination. If there is a risk of such a spread, an attempt should first be made to remove the contamination locally with absorbent material, and, if necessary, with a proper masking of the adjacent non-contaminated areas of the skin. A non-contaminated open wound should be protected.

After each decontamination operation, the treated place should be dried with a fresh non-contaminated towel or swab, and monitored. All towels and swabs used in the decontamination process should be treated as contaminated material.

While decontaminating the face, special care should be taken not to contaminate the eyes or lips.

Decontamination of the eyes should be undertaken immediately. Not only the radioactive isotope is to be considered, but also the chemical nature of the contaminant and eventual complications due to foreign bodies and mechanical or chemical irritants. Additional irritation of the eyes by decontamination procedures should be avoided. Immediate irrigation of the eyes with a copious amount of water or with appropriate medically approved solutions is recommended. Immediate irrigation of the eyes for a minimum of 15 minutes using a plumbed eyewash is recommended. After this first procedure every case of contamination of the eyes should be submitted to medical control and further treatment.

Attempts to remove contamination which resists washing should only be made under medical supervision.

8. **Loss or Theft of Radioactive Materials**

In case of loss or theft of radioactive materials, or suspected loss or theft of radioactive materials, contact the Security Office immediately. Ask them to contact the Radiation Safety Officer.

9. **Supplement to Radiation Emergency Procedures for Security Officers**

a. Upon receiving an emergency call, the Security Officer should collect the following information: the location and time of the incident, kind of incident, whether fire or medical assistance is needed, the name and telephone number of the caller, and the type and quantity of radioactive material involved.

b. An officer should be sent to the scene of the incident to assist and to control entry and exit from the area. No one is to be permitted to leave unless he/she has been monitored for radioactive contamination by a trained person. Do not eat, drink, or smoke in the incident area, or use food or drink which may have been in contact with radioactive material. Do not handle, use, or remove from the incident area any material, equipment, or other items suspected to be contaminated unless released by Radiation Safety personnel.

c. The Security Dispatcher should summon emergency fire or medical aid as needed.

d. The Radiation Safety Officer or a member of the Radiation Safety Committee MUST be contacted.

e. When reaching the scene of an incident, Security Officers should help determine if any injured persons need emergency care, and take steps to provide it.

f. Personnel and vehicles involved in the transport of radiological accident victims should not leave the Emergency Room until checked by Radiation Safety personnel.

g. When a transportation incident involves radioactive material, do not move vehicles, shipping container, or wreckage, except to rescue people. Detour pedestrians and vehicular traffic. If right-of-way must be cleared before radiological assistance arrives, move vehicles and debris the shortest distance required to open a pathway.

10. Incident Reporting to Press and Public

Because of concern about radiation on the part of the media and nonscientific public, it is the policy of the Radiation Safety Committee that all releases to the press and public be made by the **Director of College Relations**. No other person is authorized to speak on behalf of Hamilton College.

11. Supplement to Emergency Procedures for Radiation Safety Personnel

a. Procedures on Receiving Notification of an Accident

1) Upon receiving a call, the Radiation Safety personnel should collect the following information: location of the accident, number of injured persons, brief indication of the type of radiation exposure involved, and name and telephone number of individual reporting the accident.

2) Radiation Safety personnel should obtain radiation detection equipment and proceed to the location of the accident as quickly as possible.

3) If the accident involves possible radioactive contamination of an injured individual, arrange for the Radiation Safety Officer or a member of the Radiation Safety Committee to go immediately to the medical facility where the victim has been taken.

4) If the accident would appear to be of such magnitude that it **needs** to be reported either to the State of New York Department of Health, Radiation Safety personnel shall initiate the collection of appropriate information and notify Security for documentation purposes.

5) Arrange for medical examinations of all individuals who may have received a total effective dose equivalent of 25 rems or more; an eye dose equivalent of 75 rems or more; a shallow-dose equivalent to the skin of extremities of 250 rads or more; or exposure to released radioactive material in concentrations which, if averaged over a period of 24 hours, would have received an intake five times the occupational annual limit on intake.

b. Procedures for Accident Involving Release of Radioactive Material

1) Ascertain the types and amount of radioactive material involved.

2) Remove individuals from contaminated areas and take steps to minimize spread of contamination. Save all items of contaminated clothing, personal effects, etc.

3) Get complete names, birth dates, social security numbers, and addresses of all individuals involved in the accident. Keep them at the scene until all necessary information has been obtained.

4) Start survey operations to establish magnitude of possible exposure to the individuals involved.

5) Start survey of contamination levels for laboratories and equipment.

c. For Accidents Involving Overexposure to External Sources of Ionizing Radiation

1) Get names of all individuals involved in the accident.

2) Check radiation levels in areas accessible to personnel to avoid risk of further exposure to any individuals, including Radiation Safety personnel.

3) Start measurements designed to quantitate the extent of radiation exposure to individuals involved.

P. RADIOACTIVE WASTE DISPOSAL PROCEDURES

1. Introduction

Radioactive waste (radwaste) disposal can be a messy, expensive, and time-consuming problem. All users of radioactive materials have a responsibility to minimize the volume of radwaste and to label it accurately so that it can be disposed of in an economical manner consistent with protecting human welfare and the biosphere. Records of radioactive waste disposal must be maintained to satisfy legal requirements and to decide the best method of disposal. Since radwaste may also be a toxic chemical hazard, a fire or explosion hazard, a biohazard, or some combination of these, care must be taken to ensure safe packaging and disposal from many points of view.

Handling and packaging of radwaste as well as recordkeeping are the responsibility of the Authorized User. The Authorized User will transfer his/her waste to the hot-lab for storage and/or disposal. Waste drum delivery, pickup, and shipping are the responsibility of the Radiation Safety Officer.

2. Treatment and Packing of Radwaste

a. General Considerations

1) Fire or explosion hazards must be considered. Waste drums containing flammable solvents, such as liquid scintillation cocktails, must be stored in well-ventilated areas.

2) Radioactive waste must be stored in a "Restricted Area," meaning a locked room. Radwaste may not be stored in a hall or other public area.

3) The volume of radioactive waste must be kept to a minimum. **Do not use radwaste containers for non-radioactive waste.**

b. Sanitary Sewer Disposal. **NO** radioactive waste may be disposed of by Authorized Users in the sanitary sewer **except in the designated hot-lab sink.** The liquids to be disposed of must be nontoxic, pH-neutral and readily soluble (or readily dispersible biological material) in water. Primary washwater is to be treated as liquid radioactive waste. Authorized Users generating large volumes of aqueous waste should contact the RSO. Any person disposing of radioactive material to the sanitary sewer system must update the disposal log maintained at the hot-sink.

c. Solid Waste. Disposable labware, absorbent paper, gloves, contaminated articles, and any other dry or solid radwaste may be placed in a bag in a waste receptacle maintained by the Authorized User. When the bag is full, seal it and label with a radiation tag or tape containing the following information: radioisotope, activity, date and generator. Deliver the waste to the hot-lab and place in the appropriate waste container. **Update the container's inventory sheet.**

d. Aqueous Waste. Acidic or basic aqueous waste must be neutralized. **Do not** mix aqueous and hazardous chemical waste. The wastes should then be collected in bottles marked with a radiation label that includes the following information: radioisotopes, total activity, activity per milliliter, date and generator name. **Do not** put absorbent in bottles. When the bottle is full, deliver to the hot-lab for storage or disposal.

e. Liquid Scintillation Vials. Liquid scintillation vials containing hazardous materials (toluene, xylene) shall be kept separated from vials containing biodegradable materials. Vials shall be placed in a flat or box labelled as is aqueous waste above, and delivered to the hot-lab for storage and/or disposal. **Vials containing less than 0.05 μCi/ml of H-3 or C-14 should be segregated since they are deregulated as radwaste and are disposed of with regard only to their chemical characteristics.**

f. Animal Carcasses. Radioactive animal remains must be double-bagged in poly, boxed if possible, and frozen by the Authorized User. A label shall be attached to the bags or box indicating the radioisotopes, total activity, activity per animal (μCi/gm), date and generator name. Arrangements will be made with the Radiation Safety Officer to pick up the carcass prior to shipment.

3. **Decay in Storage**

Radioactive material with a physical half-life of less than 90 days (P-32, S-35 and I-125) will be ``decayed in storage (DIS)." The following procedure will be followed.

a) It is the responsibility of the Authorized User to segregate his/her associated radioactive waste according to isotope and form. If any long-lived radioisotopes are introduced into the DIS waste stream the waste may not be decayed in storage.

b) When an Authorized User fills an associated waste container he/she shall transport the waste to the hot-lab, place it in the appropriate waste receptacle and update the inventory sheet (Form RSO-9).

c) When the container in the hot-lab is full the Radiation Safety Officer will properly seal it and attach an identification label that includes the date sealed, the longest-lived radioisotope in the container, the date corresponding to 10 half-lives. The RSO will then initial the label as the person sealing the container.

d) The RSO will store the container in a designated storage area for a period of at least 10 half-lives.

e) After the specified time period the waste will be surveyed by the RSO as follows:

1) Obtain an appropriate survey instrument and check for proper operation;

2) Plan to monitor in a low background level (<0.05 mR/h) area;

3) Remove any shielding from around the container;

4) Monitor all surfaces of each individual container;

5) If the radiation level measured on the waste is indistinguishable from background, the material may be disposed of without regard to radioactivity. Ensure that all radioactive labels are removed prior to disposal.

6) Waste with activity noticeable above background must be returned to the storage area for further decay or transferred for burial.

4. Recordkeeping

The Authorized User is required to maintain two kinds of records:

a. A permanent file record of all radioactive materials disposed, including nuclide, activity, date disposed, and form.

b. An entry on the drum label each time material is placed in the radwaste drum, including nuclide, activity, date disposed, and form.

c. In general, records of radwaste activity should be accurate to one significant figure. If this is not possible, an order-of-magnitude estimate **MUST** be made, e.g., 1, 10, 100, or 1,000 μCi.

Q. ANIMAL USE PROCEDURES

1. Animals and Radioactive Materials: Rules and Procedures for Authorized Users

a. Labeling and Posting. It is the responsibility of the Authorized User to ensure that cages are properly labeled and that rooms are properly posted.

1) Cages must be tagged with yellow tags bearing the radiation symbol if they contain animals with more than one-tenth of the limits specified in Appendix 16-A, Table 9 to the NY State Sanitary Code Chapter I. The radionuclide, date, activity (in mCi), and name and phone of the Authorized User (or technician) must be marked on the tag.

2) Rooms must have a "Caution - Radioactive Materials" sign on the door if they contain more than ten times the value for the nuclide in question listed in Appendix 16-A, Table 9 to the NY State Sanitary Code Chapter I.

b. Authorized Users must make every effort to ensure the containment of radioactive waste by the use of underpads, excreta collection, etc., as appropriate. The Authorized User must take responsibility for ensuring that radioactive waste is properly disposed of and recorded. Contact the Radiation Safety Officer for directions on carcass disposal.

c. Special instructions for caretakers must be written and posted on or near the animal cages. Investigators should provide for the possibility of death or illness in the animals with special instructions. Otherwise the carcass may be irretrievably disposed as radioactive waste.

d. In cases where the cages or room must be specially cleaned or decontaminated, the Authorized User is responsible for cleaning or supervising the cleaning.

e. The Radiation Safety Officer will determine if film badges are needed by animal care personnel, if the animal quarters should be a restricted area, and any other precautions which must be taken.

f. The Authorized User will be responsible for ensuring that animal rooms, which are restricted areas, will be locked or otherwise secured when not attended by Authorized Users.

g. Radioactive animals may not leave the institution except as specifically authorized by the RSO on a case by case basis.

2. Animals and Radioactive Materials: Rules and Procedures for Animal Caretaker (Radioactive Animals, Carcasses, Waste, and Cages).

All cages bearing the tag or label "CAUTION - RADIOACTIVE MATERIALS" and the radiation symbol should be treated according to the following procedures.
a. Personal Protection

1) Wear film badge (if provided). For many kinds of radioactivity, film badges are not needed.

2) Always wear disposable gloves and lab coat or other protective clothing. Do not allow animals, waste, cages, etc., to touch bare skin.

3) Before eating, drinking or smoking, etc., wash hands and any skin which may have become contaminated. Notify the Radiation Safety Officer of personal contamination.

b. Routine Operations

1) Feeding and watering may be carried out as with other animals unless otherwise specified.

2) Underpads, urine, feces, and other waste should be disposed of in containers provided by Radiation Safety, not in ordinary waste. These are usually yellow metal drums marked "CAUTION RADIOACTIVE MATERIALS." When a container is full, call Radiation Safety Officer for disposal.

3) Cages must be treated as contaminated until washed. Identifying tags should not be removed until the cage has been cleaned.

4) Cages and room must be surveyed by the supervisor prior to release as clean. If there are any questions, the supervisor may request Radiation Safety assistance.

5) When animals are transferred to clean cages, be sure that the new cages are labeled.

c. Non-Routine Operations

1) For sick, dying, or dead radioactive animals, call the Authorized User. If previous instructions have been given, follow them.

2) Carcass:

-Any identifying tags, collars, etc. must be removed and saved.

-The carcass must be double bagged in plastic with absorbent material. The bagged animal must be placed in a box and frozen. The box must be labeled ``Radioactive Animal Remains," with radionuclide, date, activity, and Authorized User's name. Remains must be stored in a freezer for pickup by Radiation Safety or Receiving Personnel. The outside of the box must not be contaminated.

R. Inventory Control And Maintenance Procedures for Radioactive Materials

1. Authorized Users shall perform a physical inventory of all radioactive materials at the end of each calendar quarter. This inventory shall be documented on a Form RSO-10 and submitted to the Radiation Safety Officer.

2. Institutional totals for all radionuclides will then be recorded from these inventory forms. This will serve as a secondary method of inventory control.

3. Radioactive material use and disposal information will be kept by Authorized Users on Form RSO-12. These records will be reviewed periodically by the Radiation Safety Officer and will assist in inventory control.

4. Prior to termination at Hamilton College, an Authorized User will work with the RSO to ensure all radioactive materials are properly controlled and accounted for.

S. PROCUREMENT OF RADIOACTIVE MATERIALS

1. Purchasing Procedures

a. All orders for radioactive material will be originated by an Authorized User. Authorized Users requesting radioactive materials should fill out a Form RSO-11 and submit it the Radiation Safety Officer.

The following information is to be specified on the form:

Description; catalog number if possible.
Radionuclide (e.g., C-14);
Activity (e.g., 2.0 mCi, or 3 x 50 μCi, etc.)
Quantity
Total Price
Date needed by

b. Each request for radioactive materials will be approved by the Radiation Safety Officer prior to purchase. The RSO will compare the User's request with the User's Authorization sheet, RSO-2, to ensure that the Authorized User does not exceed his/her individual possession limits.

c. Each order for radioactive materials will also be recorded on a master purchase and receipt log to ensure that institutional total possession limits are not exceeded.

d. Once the RSO has verified that the material requested will not exceed specified limits, the RSO will place the order for the material.

e. Radioactive materials will be shipped directly to the Radiation Safety Officer.

f. The above procedures can be modified by the RSO, in case of emergency or immediate need for short-lived radioactive materials, provided that all administrative, legal, record-keeping, receiving, and survey requirements are met.

2. Receiving Procedures

a. Radioactive materials will be received at the Mail Center.

b. The person receiving the shipment will perform the following duties with regard to radiative materials packages:

1) Observe the package. If the package appears to be damaged, ask the carrier to remain at the site until it can be determined that neither the driver nor the delivery vehicle is contaminated.

2) Contact the RSO or designated alternate on call immediately, and inform of the delivery and provide information concerning the contents of the package as externally provided. During off-duty hours, a message regarding the package delivery will be left on the phone-mail system.

3) Deposit the package in the designated secure place pending pickup by Radiation Safety personnel.

c. Packages will be opened and surveyed according to NY State Sanitary Code Chapter I, Part 16.16 and good radiological practice, and surveys will be recorded. These surveys shall be performed within 3 hours of package receipt if received during normal working hours or not later than 3 hours from the beginning of the next working day if it is received after working hours.

Packages requiring monitoring include those that are:

1) **Labeled** as containing radioactive material, e.g., White I, Yellow II and Yellow III.

   White I - Indicates a low external radiation level; ≤ 0.5 mR/h.

   Yellow II - Package may have external radiation level or fissile properties; 0.5 - 50 mR/h.

   Yellow III - > 50 mR/h

2) Potentially damaged, e.g., crushed, wet, broken, etc.

Packages exempted from survey by NY State Sanitary Code Chapter I, Part 16.16 will also be logged in.

All packages which require monitoring will be treated as follows:

- Packages will be visually examined for damage and leakage.
- Package exteriors will be surveyed with an appropriate instrument, e.g., a GM counter, micro REM meter, or a scintillation counter, and smears taken and counted in a liquid scintillation counter or gamma scintillation counter.
- Packages will be opened with rubber gloves and appropriate remote handling equipment, if necessary. Shielding precautions will be observed as appropriate for the nuclide, activity, and packaging involved. Stock vials will be wiped to monitor contamination. Contents will be verified to ensure agreement between order and receipt.
- Packaging materials will be checked for radioactivity and, if free of contamination, may be discarded in ordinary trash after radioactive labels have been removed or defaced.

For packages which do not require monitoring the contents will be verified to ensure agreement between order and receipt.

d. The radiation safety person performing the receipt survey will enter the associated survey information on the Radionuclide Receipt Form (RSO-11) and enter the initial information on a Radioactive Material Use and Disposal Form (RSO-12). The package will then be delivered by radiation safety personnel to the Authorized User, along with a copy of Form RSO-12 on which to record use and disposal. In the event the Authorized User is not available, a Qualified User working for the Authorized User may sign for the package. Material that cannot be delivered due to the absence of the Authorized or Qualified User will be stored in the hot-lab until delivery can be made. The Form RSO-11 will then be completed by listing the person delivered to, date and time. File the form for future reference.

T. TRANSFER AND TRANSPORT OF RADIOACTIVE MATERIAL

1. All TRANSFER of licensed radioactive materials, either within Hamilton College or to individuals or institutions outside of Hamilton College, must be approved and recorded by the Radiation Safety Officer prior to actual physical transfer.

   a. Transfer within Hamilton College. Transfer of licensed radioactive material can occur only between Authorized Users and only with prior RSO approval. A brief written notification must be filed by **both** parties with the RSO after transfer. Packaging considerations will be handled by the RSO.

   b. Transfer outside of Hamilton College. All transfer of licensed radioactive material to individuals or institutions outside of Hamilton College will be done by the RSO. Federal and state regulations require license verifications, special packaging and labeling, and recordkeeping which must be done by the RSO.

2. TRANSPORT of radioactive materials is divided into several classes. In all cases, materials producing external radiation should be shielded to keep radiation levels ALARA.

   a. For transport BETWEEN ROOMS in the same building, precautions should be taken to minimize the possibility of spills or releases, but no special packaging is required as long as the material is accompanied by an Authorized User.

   b. For foot transport BETWEEN BUILDINGS, radioactive materials should be shielded as above, and packed so that there will be no spills or releases in the event the package is dropped. Only an Authorized User may transport the material and he/she will exercise special care in crossing streets.

   c. For VEHICULAR TRANSPORT, regardless of distance, radioactive materials must be shielded as above and packaged according to Department of Transportation specifications. Consult the Radiation Safety Officer.

U. LEAK TEST PROCEDURE

Each sealed source, containing radioactive material other than H-3, with a half-life greater than 30 days shall be leak tested at least once every 6 months unless the source is designed to emit alpha particles then the source shall be leak tested at least once every 3 months. A source is exempt from this leak testing requirement if the source contains 100 microcuries or less of beta and/or gamma emitting material or 10 microcuries or less of alpha emitting material.

Leak tests will be performed using the following procedure.

1. Obtain a Form RSO-7 and completely fill in all the initial information requested.

2. Obtain 2 Q-Tip swabs and 2 small zip-lock bags. Wet one of the swabs with isopropyl alcohol (the swab should just be damp, not saturated).

2. Select the surface to be surveyed.

CAUTION
DO NOT ATTEMPT to rub the enclosed cotton swabs directly on the sealed source capsule. This might cause excessive and unnecessary personnel radiation exposure.

The site selected for the test should be an area **near** where the source is located when not in its shielded housing. This could be the outside of a shutter, or a tube through which the source passes. The surface area wiped should be representative of where, if the source *were* leaking, the contamination would be likely to end up.

The area covered by the wipe survey should be as large as is reasonable. It should be 2 in^2 minimum up to a maximum of about 16 in^2.

3. Rub the damp swab over the area you have selected for the wipe test. Place the swab in a plastic bag and seal it.

4. Take the dry cotton swab and rub it over the same area that you rubbed the damp swab over. Place this dry swab in the other plastic bag and seal it.

5. Place the wipe in an appropriate counting instrument and analysis for the radioactivity of concern. This detection method should be capable of detecting (i.e., have an MDA of) at least 0.005 μCi of total* activity. Report the results on the Form RSO-7 and file for future reference.

*Total activity means that the activity present on both swabs must be added together.

6. The MDA of the counting procedure can be determined by using the following formula:

$$MDA = \frac{2.71 + 2(m)\sqrt{(R_b)(t_s)\left(1 + \frac{t_s}{t_b}\right)}}{(t_s)(eff_c)}$$

where: R_b = background count rate
t_b = background count time
t_s = sample (and background) count time
eff_c = counting instrument efficiency

V. HUMAN USE OF RADIOACTIVE MATERIALS

Hamilton College does not hold a license for the human use of radioactive material, whether for diagnosis or therapy, if such use is *in vivo* or involves exposure of a patient to radiation from licensed radioactive materials. *In vitro* laboratory procedures used in research, even if involving biological materials of human origin, are not considered to be human use.

W. RADIATION MACHINE SUPERVISOR RESPONSIBILITIES

1. **The supervisor of any radiation machine is responsible for:**

a. Providing written operating, safety, and emergency procedures for the equipment.

b. Assuring the personnel are aware of and follow proper procedures in the use of the equipment and the radiation hazards associated with this operation.

c. Notifying the Radiation Safety Officer when there is any change in the setup; i.e., new equipment installed, changes in shielding, change in output of radiation, or change in usage of the unit.

2. **The operator of any radiation machine is responsible for:**

a. Wearing appropriate monitoring devices.

b. Keeping exposure as low as reasonably achievable. Personnel shall make full use of protective barriers, lead aprons, and gloves as applicable.

c. Observing any restrictions on the use of the unit.

d. Notifying the Radiation Safety Officer immediately of any accidental exposures to radiation.

e. Keeping the unit disconnected or locked when not in actual use.

f. The operators of radiation machines shall be familiar with the standards for radiation protection.

X. POLICIES AND PROCEDURES FOR RADIATION MACHINES AND AREAS

1. Those using radiation machines must be authorized by the Radiation Safety Committee.

2. All operating personnel and personnel in the immediate area shall be required to wear appropriate film badge or other dosimeter.

3. All areas in which radiation machines are located or being used shall be posted with the required radiation caution sign.

4. The structural shielding requirements of any new installation, or an existing one in which changes are contemplated shall be discussed with and approved by the Radiation Safety Officer.

5. A radiation survey shall be made of all new installations. Existing installations will be surveyed at least **quarterly** and after every change that might increase the radiation hazard.

RESERVED

Z. GLOSSARY

Absorbed Dose. When ionizing radiation passes through matter, some of its energy is imparted to the matter. The amount of energy absorbed per unit mass of irradiated material is called the absorbed dose, and is measured in rads or grays. 1 Gy = 100 rad.

Activity. The rate of disintegration (transformation) or decay of radioactive material. The units of activity are the curie (Ci) and the becquerel (Bq). 1 Ci = 3.7E+10 dps = 2.22E+12 dpm. 1 Bq = 1 dps.

Acute Dose. A large dose of radiation (far in excess of federal dose limits) delivered in a short period of time (a few hours).

Airborne Contamination. Radioactive material dispersed in the air as dusts, fumes, particulates, mists, vapors, or gases.

Airborne Radioactivity Area. A room, enclosure, or area in which airborne radioactive materials, composed wholly or partly of licensed material, exist in concentrations in excess of the derived air concentrations (DACs) specified in appendix B to 10 CFR 20, or to such a degree that an individual present in the area without respiratory protective equipment could exceed, during the hours an individual is present in a week, an intake of 0.6 percent of the annual limit on intake (ALI) or 12 DAC-hours.

ALARA. Acronym for ``as low as is reasonably achievable"; means making every reasonable effort to maintain exposures to radiation as far below the dose limits as is practical consistent with the purpose for which the licensed activity is undertaken. In making this assessment the state of technology, the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations, and in relation to using nuclear energy and licensed materials in the public interest may all be taken into account.

Alpha Decay. Radioactive decay in which an alpha particle is emitted. This lowers the atomic number (Z) of the nucleus by two and its mass number (A) by four.

Alpha Particle. A positively charged particulate radiation consisting of two protons and two neutrons, emitted during a nuclear transformation. It can be stopped by a few sheets of paper.

Annual Limit on Intake (ALI). The limit for radioactive material taken into the body of an adult worker by inhalation or ingestion in a year. Inhalation or ingestion of one ALI will result in a committed effective dose equivalent of 5 rems (0.05 Sv) to the whole body, or a committed dose equivalent of 50 rems (0.5 Sv) to any individual organ or tissue. ALI values are given in table 1 columns 1 and 2 of appendix B to 10 CFR 20.

Attenuation. The reduction of a quantity of radiation as it passes through matter, resulting from all types of interaction with that matter.

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

Becquerel (Bq). A unit of radioactivity equal to one disintegration per second.

Beta Decay. Radioactive decay in which a beta particle is emitted.

Beta Particle. A negatively charged particle emitted from an atom during radioactive decay. A beta particle has the same mass as an electron, which is equal to that of a proton. A beta particle can be stopped by an inch of wood or a thin sheet of aluminum.

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

Byproduct Material. Any radioactive material (except special nuclear material) yielded in, or made radioactive by, exposure to the radiation incident to the process of producing or using special nuclear material; and tailings or wastes produced by the extraction or concentration of uranium or thorium from ore processed primarily for its source material content, including discrete surface wastes resulting from uranium solution extraction processes. Underground ore bodies depleted by these solution extraction operations are not byproduct material within this definition.

Collective Dose. The sum of the individual doses received in a given period by a specified population from exposure to a specified source of radiation.

Committed Dose Equivalent (HT,50). The dose equivalent which will be delivered to the organs or tissues of reference (T), during the 50-year period following an intake of radioactive material by an individual.

Committed Effective Dose Equivalent (HE,50). The sum of the products of the weighing factors applicable to each body organ or tissue irradiated and the committed dose equivalent to these organs or tissues ($H_{E,50} = \Sigma w_T H_{T,50}$).

Contamination. Radioactive material in a form that's easily spread around (e.g., liquid, powder), in a place where it's not supposed to be, or in a place which is believed to be uncontaminated. Since this material is radioactive, it emits radiation.

Contaminated Area. An area within a restricted area in which radioactive materials are not or may not be specifically contained. That is, they are or may be present on surfaces within the contaminated area.

Controlled Area. An area, outside a restricted area but inside a site boundary, access to which can be limited by the licensee for any reason.

Count (radiation counters). (1) A pulse that has been registered, corresponding either to an ionizing event or to an extraneous disturbance (spurious count). (2) The number of pulses recorded in a specific period.

Counter Tube, Geiger-Müller. A gas-filled radiation counter tube operated in that range of applied voltage in which the charge collected per isolated count is independent of the charge liberated by the initial ionizing event, that is, the Geiger-Müller region.

Counter Tube, Proportional. A gas-filled radiation counter tube operated in that range of applied voltage in which the charge collected per isolated count is proportional to the charge liberated by the original ionizing event. The range of applied voltage depends on the type and energy of the incident radiation.

Curie (Ci). The basic unit to describe the quantity of radiation given off by a sample of material. The curie is equal to 37 billion disintegrations per second (3.7E+10 dps or 2.22E+12 dpm). This is approximately the rate of decay of one gram of radium-226.

Decay, Radioactive. Elements that give off radiation are in an unstable state. They continue to give off radiation until they reach a stable, non-radioactive state. This process is known as radioactive decay. An unstable element will decay into one or a string of different elements as it undergoes radioactive decay.

Decay Product. A nuclide, stable or radioactive, formed by radioactive decay.

Declared Pregnant Woman. A woman who has voluntarily informed her employer, in writing, of her pregnancy and the estimated date of conception.

Deep-dose Equivalent (Hd). Applies to external whole-body exposure; it is the dose equivalent at a tissue depth of 1 cm (1000 mg/cm^2).

Decontamination. Removal or reduction of radioactive material.

Derived Air Concentration (DAC). The concentration of a given radionuclide in air that, if breathed by the reference man for a working year of 2000 hours under conditions of light work (inhalation rate 1.2 cubic meters of air per hour), results in an intake of one ALI. DAC values are given in table 1 column 3 of appendix B to 10 CFR 20.

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

Detector. Any device for converting radiation flux to a signal suitable for observation and measurement.

Disintegration, Nuclear. A spontaneous nuclear transformation characterized by the emission of energy and/or mass from the disintegrating nucleus.

Dose or Radiation Dose. A generic term that means absorbed dose, dose equivalent, effective dose equivalent, committed dose equivalent, committed effective dose equivalent, or total effective dose equivalent, as defined in specific paragraphs of 10 CFR 20.

Dose, Accumulated. The sum of the absorbed doses received by the system considered, despite whether it is exposed to radiation in a continuous or discontinuous fashion (also called dose, cumulative absorbed).

Dose Equivalent (HT). The product of the absorbed dose (rad) in tissue, quality factor, and all other necessary modifying factors at the location of interest. The units of dose equivalent are the rem and sievert (Sv).

Dose Rate. The rate at which radiation dose is absorbed.

Dosimeter. A device, such as a film badge, thermoluminescent dosimeter (TLD), or pocket ion chamber which can be worn and used to measure the radiation dose a person receives over a period of time.

Effective Dose Equivalent (HE). The sum of the products of the dose equivalent to the organ or tissue (HT) and the weighing factors (wT) applicable to each body organ or tissue that is irradiated ($HE = \Sigma wTHT$).

Electron Volt. The amount of kinetic energy gained by an electron when it is accelerated through a voltage difference of one volt.

Exposure. Being exposed to ionizing radiation or to radioactive material.

Exposure Rate. The exposure per unit time.

External Dose. That portion of the dose equivalent received from radiation sources outside the body.

Extremities. Hand, elbow, arm below the elbow, foot, knee, and leg below the knee (revised 10 CFR 20).

Eye Dose Equivalent. Applies to the external exposure of the lens of the eye and is taken as the dose equivalent at a tissue depth of 0.3 cm (300 mg/cm^2)

Film Badge. A package of photographic film worn like a badge by workers in the nuclear industry to measure exposure to ionizing radiation. The absorbed dose can be calculated by the degree of film darkening caused by the irradiation.

Fixed Contamination. The fraction of radioactivity present that cannot be easily removed or dislodged. It might be in the pores of a piece of wood, in the cracks between floor tiles, or in other hard-to-remove locations.

Gamma Rays. High energy, short wavelength electromagnetic radiation, similar to x rays. Gamma radiation is released when fission occurs and often when a radionuclide decays. Gamma rays are very penetrating and are best shielded by dense materials, such as lead, water, or concrete.

Genetic Effects. Radiation effects that produce changes in egg or sperm cells of the exposed individual, and therefore affect offspring of the exposed individual.

Gray (Gy). The International System of Units (SI) unit of absorbed dose. One gray is equal to an absorbed dose of 1 joule/kilogram (100 rads).

Half-Life, Biological. The time required for a particular substance in a biological system to be reduced to one-half of its original value by biological processes when the rate of removal is approximately exponential.

Half-Life, Effective. The time required for a particular radionuclide in a system to be reduced to one-half its value from both radioactive decay and other processes such as biological elimination and burn-up when the rate of removal is approximately exponential.

Half-Life, Radioactive. For a single radioactive decay process, the time required for the activity to decrease to one-half its value by that process.

Half-Value Layer. The thickness of a specified substance that, when introduced into the path of a given beam of radiation, reduces it to one-half the original intensity. It is sometimes expressed in terms of mass per unit area (also called half-value thickness).

Health Physics. The art and science concerned with recognition, evaluation, and control of health hazards from ionizing radiation.

High Radiation Area. (1) Any area in which a major portion of the whole body could receive a radiation dose of 100 millirem in one hour (10 CFR 20). (2) An area, accessible to individuals, in which radiation levels could result in an individual receiving a dose equivalent in excess of 0.1 rem (1 mSv) in one hour at 30 cm from the radiation sources or from any surface that the radiation penetrates (revised 10 CFR 20).

Hormesis. Beneficial results from radiation received, potentially improving the health or extending the life span of the organism.

Hot. An expression commonly used to mean ``highly radioactive."

Individual Monitoring. (1) Assessment of dose equivalent by using devices designed to be worn by an individual. (2) Assessment of committed effective dose equivalent by bioassay (see Bioassay) or by determination of the time-weighted air concentrations to which an individual has been exposed, i.e., DAC-hours. (3) Assessment of dose equivalent by using survey data.

Individual Monitoring Devices. Devices designed to be worn by a person for the assessment of dose equivalent, such as: film badges, TLDs, pocket ionization chambers, and personal (lapel) air sampling devices.

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

Ionization. Any process by which an atom, molecule, or ion gains or loses electrons.

Ionization Chamber. A gas-filled enclosure for measuring radiation by means of ions produced therein.

Ionizing Radiation. Any radiation displacing electrons from atoms or molecules, thereby producing ions. Examples: alpha, beta, x and gamma radiation.

Irradiation. Exposure to ionizing radiation (see Exposure).

Isotopes. Different forms of the same chemical element that are distinguished by having different numbers of neutrons in the nucleus. A single element may have many isotopes. For example, the three isotopes of hydrogen are protium (H), deuterium (H), and tritium (H).

Licensed Material. Source material, special nuclear material, or byproduct material received, possessed, used, or transferred under a general or specific license issued by the NRC.

Limits. The permissible upper bounds of radiation doses.

Lost or Missing Licensed Material. Licensed material whose location is unknown. It includes material that has been shipped but has not reached its destination and whose location cannot be readily traced in the transportation system.

Member of the Public. Any individual either in a restricted (controlled) or unrestricted area. However, an individual is not a member of the public during any period in which the individual is a radiation worker and receives an occupational dose.

Minor. An individual less than 18 years of age.

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

Neutron. An uncharged elementary particle with a mass slightly greater than that of the proton and found in the nucleus of every atom heavier than hydrogen-1 (H). Neutrons sustain the fission chain reaction in a nuclear reactor.

Non-stochastic Effect. Health effects, the severity of which vary with the dose, and for which a threshold is believed to exist. Radiation-induced cataract formation is an example of a non-stochastic effect.

Nuclear Regulatory Commission (NRC). The independent civilian agency of the federal government with the authority to regulate, inspect, and oversee the nuclear industry.

Occupational Dose. The dose received by an individual in a restricted area or during employment in which the individual's assigned duties involve exposure to radiation and to radioactive material from licensed and unlicensed sources of radiation, whether in the possession of the licensee or other person. Occupational dose does not include dose received from natural background, as a patient from medical practices, from voluntary participation in medical research programs, or as a member of the public.

Photon. A quantum of electromagnetic radiation.

Planned Special Exposure. An infrequent exposure, separate from and in addition to the annual dose limits.

Positron. An elementary particle with the mass of an electron but charged positively. It is the ``anti-electron."

Public Dose. The dose received by a member of the public from exposure to radiation and to radioactive material released by a licensee, or to another source of radiation either within a licensee's controlled area or in unrestricted areas. It does not include occupational dose, dose received from natural background, as a patient from medical practices, or from voluntary participation in medical research programs.

Quality Factor. The modifying factor used to derive dose equivalent from absorbed dose.

Rad (acronym for radiation absorbed dose). The special unit of absorbed dose. One rad is equal to an absorbed dose of 100 ergs/gram or 0.01 joule/kilogram (0.01 gray).

Radiation. Alpha particles, beta particles, gamma rays, x rays, neutrons, high-speed electrons, high-speed protons, and other particles capable of producing ions. Radiation, as used here, does not include non-ionizing radiation, such as sound, radio, or microwaves, or visible, infrared, or ultraviolet light.

Radiation Area. (1) Any area accessible to personnel in which there exists radiation originating in whole or in part within licensed material at such levels that a major portion of the whole body could receive in any one hour a dose in excess of 5 millirem, or in any five consecutive days a dose

in excess of 100 millirems (10 CFR 20). (2) An area, accessible to individuals, in which radiation levels could result in an individual receiving a dose equivalent in excess of 5 mrem (50 μSv) in one hour at 30 cm from the radiation source or from any surface that the radiation penetrates (revised 10 CFR 20).

Radiation Source. An apparatus or a material emitting or capable of emitting ionizing radiation.

Radioactive. Exhibiting radioactivity.

Radioactive Decay. The process by which radioactive material emits energy in the form of radiation.

Radioactive Decay Chain or Decay Series. A series of nuclides in which each member transforms into the next through radioactive decay (not including spontaneous fission) until a stable nuclide has been formed. U-238, U-235 and Th-232 are at the beginning of three such decay chains.

Radioactive Material. A material of which one or more of its parts exhibit radioactivity.

Radioactivity. The property possessed by the nuclei of some elements (such as uranium) of spontaneously emitting radiation.

Radioactivity, Natural. Radioactivity of naturally occurring nuclides.

Radioisotope. An unstable isotope of an element that decays or disintegrates spontaneously, emitting radiation. More than 1300 natural and artificial radioisotopes have been identified.

Radiologically Controlled Area (RCA). Any area to which access is controlled because of the presence of radiation or radioactive materials may be called an RCA. It may also be called a restricted area.

Radionuclide. A radioactive nuclide.

Radiosensitivity (radiation protection). The relative susceptibility of cells, tissues, organs, organisms, and other substances to the injurious action of ionizing radiation. Radio-resistance and radiosensitivity are usually employed in a comparative sense, rather than in an absolute one.

Rem (acronym for roentgen equivalent man). The special unit of dose equivalent. The dose equivalent in rems is equal to the absorbed dose in rads multiplied by the quality factor (1 rem = 0.01 sieverts).

Removable Contamination. Loose or smearable radioactive material present on a surface that can be transferred to a smear medium by rubbing with moderate pressure. It can also be picked up unknowingly on shoes, hands, and clothing.

Respiratory Protective Device. An apparatus, such as a respirator, used to reduce the individual's intake of airborne radioactive materials.

Restricted Area. An area, access to which is limited by the licensee for protecting individuals against undue risks from exposure to radiation and radioactive materials. Restricted area does not include areas used as residential quarters, but separate rooms in a residential building may be set apart as a restricted area.

Roentgen (R). A unit of exposure to gamma or x radiation (see Exposure).

RSC. Radiation Safety Committee

RSO. Radiation Safety Officer

Scintillation counter. A counter in which the light flashes produced in a scintillator by ionizing radiation are converted into electrical pulses by a photo-multiplier tube.

Scintillator. A material that gives off light when radiation interacts with it.

Shallow Dose Equivalent (Hs). Applies to the external exposure of the skin or an extremity, taken as the dose equivalent at a tissue depth of 0.007 cm (7 mg/cm^2) averaged over an area of 1 cm^2.

Shield. Material intended to reduce the intensity of radiation entering a region.

Shield, Biological. A shield whose primary purpose is to reduce ionizing radiation to biologically permissible levels.

Shielding. The use of shields. Also the material of which a shield is composed.

Sievert (Sv). The SI unit of dose equivalent. The dose equivalent in sieverts is equal to the absorbed dose in grays multiplied by the quality factor (1 Sv = 100 rems).

Smear; Smear Test. A procedure in which a swab is rubbed on a surface and the smear's radioactivity measured to determine if the surface is contaminated with loose radioactive material (sometimes called swipe).

Somatic Effects. Those results of radiation exposure which act on the person who has been exposed to the radiation.

Source Material. (1) Uranium or thorium, or any combination of uranium and thorium in any physical or chemical form. (2) Ores that contain, by weight, one-twentieth of one percent (0.05 percent), or more, of uranium, thorium, or any combination of uranium and thorium. Source material does not include special nuclear material.

Special Nuclear Material. (1) Plutonium, uranium-233, uranium enriched in the isotope 233 or in the isotope 235, and any other material that the NRC determines to be special nuclear material, but does not include source material. (2) Any material artificially enriched by any of the foregoing but does not include source material.

Specific Activity. (1) In a given sample, the activity of a radionuclide divided by the mass of the element whose radionuclide is being considered. (2) The activity of a material divided by its mass.

Spill. The accidental release of radioactive materials.

Stochastic Effects. Health effects which occur randomly and for which the probability of the effect occurring, rather than its severity, is assumed to be a linear function of dose without threshold. Hereditary effects and cancer incidence are examples of stochastic effects.

Surface Contamination. The deposition of radioactive materials on a surface.

Survey. An evaluation of the radiological conditions and potential hazards incident to the production, use, transfer, release, disposal, or presence of radioactive material or other sources of radiation. When appropriate, such an evaluation includes a physical survey of the location of radioactive material and measurements or calculations of levels of radiation, concentrations, or quantities of radioactive material present.

Survey Meter. A portable instrument that measures the exposure rate or radiation intensity.

Swipe. Synonym for smear.

Tenth-Value Layer (TVL). Thickness of an absorber required to attenuate a beam of radiation by a factor of ten.

Thermoluminescence. A process of releasing radiation-induced energy as light in response to heating.

TLD (Thermoluminescent Dosimeter). A solid state radiation dosimeter that can absorb energy that may be released later, as light, by heating the material.

Total Contamination. The sum of the fixed and removable contamination. Total contamination is usually used to set limits on material and equipment which will be unconditionally released from radiologically controlled areas.

Total Effective Dose Equivalent (TEDE). The sum of the deep-dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures).

Tracer. A nuclide introduced into a system which permits investigators to follow the behavior of some component of that system.

Unrestricted Area. An area, access to which is not controlled by the licensee for purposes of protection of individuals from exposure to radiation and radioactive materials, and any area used for residential quarters.

Very High Radiation Area. An area, accessible to individuals, in which radiation levels could result in an individual receiving an absorbed dose in excess of 500 rads (5 grays) in one hour at one meter from a radiation source or from any surface that the radiation penetrates. At very high doses received at high dose rates, units of absorbed dose (e.g., rads and grays) are appropriate, rather than units of dose equivalent (e.g., rems and sieverts) (revised 10 CFR 20).

Waste, Radioactive. Equipment and materials (from nuclear operations) that are radioactive or have radioactive particles on them and for which there is no further use. Wastes are generally

with high-speed electrons. X rays are always non-nuclear in origin.