Yale University
Office of Environmental Health & Safety

Radiation Safety Procedures

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Office of Environmental Health & Safety
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IMPORTANT TELEPHONE NUMBERS

	Telephone
EMERGENCY EHS - RADIATION SAFETY	785-3555
EMERGENCY (off hours) - CAMPUS POLICE	911
Environmental Health and Safety Main Office	785-3550
Radioisotope Authorization Information	737-2118
Isotope Orders	737-2118
Radiation Safety - BCMM laboratory · Scheduling of iodinations · Thyroid counts · Urine bioassays	785-4250
Renovation/Decommission Survey Requests	737-2121
Dosimetry Service (badges)	737-2114
Radioactive Waste Disposal Service Environmental Services Section · Waste Container Pickup Requests · Replacement Containers	432-6545
Radiation Safety Officer Tammy Stemen, CHP	737-2140
Assistant Radiation Safety Officer Kevin Charbonneau, CHP	737-2139
Laser Safety Officer George Andrews	737-2832
Chairman, Radiation Safety Committee William C. Summers, M.D., Ph.D.	785-2986

YALE UNIVERSITY

New Haven, Connecticut

RADIATION SAFETY PROCEDURES MANUAL

Prepared by: Radiation Safety Section
Office of Environmental Health & Safety
135 College Street
New Haven, CT 06510-2411
203/785-3550

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RADIATION SAFETY PROCEDURES INTRODUCTION

Radioactive materials are potentially hazardous unless used with strict adherence to safety rules and procedures. The safety rules, which govern all uses of radiation sources, are concerned with minimizing the biological effects as well as protecting the health of the exposed individual. When followed faithfully, these rules limit exposure of radiation workers to levels far below those which might cause adverse somatic or genetic effects. The rules and procedures set forth in this guide have a straightforward purpose: to protect employees and the public as much as possible against unnecessary and potentially harmful exposure to radiation.

Five stages of responsibilities are involved in the radiation safety program. These are:

1. Radiation Safety Committee: A group of scientists, physicians, and other experts appointed by the Yale University Provost to establish Yale policies and procedures governing the use of all types of radiation at Yale.

2. Radiation Safety Section (RSS): An operating unit of specially trained health physicists and technicians which is responsible for ensuring compliance with Yale policies and state and federal regulations. This section of the Office of Environmental Health and Safety (OEHS) also provides a variety of technical services to the Yale community necessary for achieving such compliance.

3. Environmental Services Section (ESS): An operating unit of specially trained personnel who are responsible for the overall management of radioactive waste generated at the University. This section of OEHS also handles biological and chemical waste issues. The ESS is a separate section from the RSS.

4. Authorized Principal Investigators: University faculty members whose training and experience are such that they have been authorized by the Radiation Safety Committee to use radiation sources in their laboratory's research activities. The Principal Investigators are responsible for their laboratory’s radiation safety compliance.

5. Individual Users: Scientists, physicians, students, research personnel, technical and other workers engaged in laboratory research and research support activities which involve the actual use and handling of radioactive materials and/or devices producing radiation. These personnel usually work under the supervision of authorized Principal Investigators.

RADIATION SAFETY COMMITTEE

The Radiation Safety Committee is composed of members appointed by the Provost of the University. The committee has jurisdiction over radiation and radioactive materials, their use, and over any equipment which produces radiation in areas under Yale control.

The Mandate of the Committee (written October 26, 1989) follows:

1. The Radiation Safety Committee shall advise the President, Provost and Director of University Safety (now Director OEHS) on policy matters concerned with the protection of personnel from radiation. The Committee shall recommend to the President, Provost and Director of University Safety guidelines relating to procedures and facilities used in research laboratories, including such matters as safety training and health surveillance.

2. The Committee shall oversee the activities of the Radiation Safety Section, in the sense that it shall (i) review its objectives and performance goals, (ii) monitor its progress in meeting those objectives and goals, and (iii) recommend changes in that section's organization and activities as it may find desirable.

3. The Committee shall meet regularly (usually monthly) to receive the progress reports of the Director of University Safety and the Radiation Safety Officer and to advise them on specific safety issues as well as on general safety policy.

4. The Committee shall offer its counsel to all University personnel regarding matters of radiation safety. The President and Provost may ask the Committee to inform the community about developments in the general area of radiation safety.

5. On matters of oversight which involve the evaluation of performance by the Radiation Safety Section, the Committee may, at the discretion of the chair, meet in executive session, in such cases the Radiation Safety Officer and the Director of University Safety shall be excused from participating and voting.

6. The Radiation Safety Committee is also responsible to carry out the duties related to the University's Nuclear Regulatory Commission (NRC) license. These are as follows:

   A. Charge: The Committee shall:

      (1) Ensure that NRC licensed material and other sources of radiations will be used safely. This includes review, as necessary, of training programs, equipment, facilities and procedures;
      (2) Ensure that licensed material is used in compliance with NRC regulations and the institution's license;
      (3) Ensure that the use of licensed material is consistent with the ALARA (as low as reasonably achievable) philosophy;
      (4) Identify program problems and recommend solutions;
      (5) Ensure that the institution's byproduct material license is amended, if required.

B. Responsibilities: The Committee shall:

(1) Be familiar with all pertinent NRC regulations;
(2) Review the training and experience of proposed authorized users and the Radiation Safety Officer (RSO) to determine that their qualifications are sufficient to enable the individuals to perform their duties safely, and are in accordance with regulations and the license;
(3) Review, on the basis of safety, and approve or deny, consistent with the limitations of the regulations and the license, all requests for authorization to use radioactive material within the institution;
(4) Review the RSO's periodic summary report of the occupational radiation exposure records of all personnel;
(5) Review programs to ensure that all persons whose duties may require them to work in, or frequent, areas where radioactive materials are used (e.g. security, housekeeping, physical plant) are appropriately instructed as required by the NRC regulations
(6) Review, at least annually, the RSO's report of the radiation safety program to determine that activities are being conducted safely, in accordance with NRC regulations and the conditions of the license;
(7) Recommend remedial action to correct deficiencies identified in the radiation safety program; and
(8) Maintain written minutes of all Committee meetings.

RADIATION SAFETY SECTION

As the operational arm of the Radiation Safety Committee, the Radiation Safety Section is responsible to:

1. Implement policy decisions of the Radiation Safety Committee and provide information, which leads to compliance with appropriate regulations.

2. Provide general surveillance of all radiation safety activities, including laboratory, personnel, and environmental monitoring.

3. Provide routine training for University personnel at various levels of responsibility on all aspects of radiation protection. Present Radiation Safety seminars upon request for laboratories with concerns about specific radioisotopes or experimental techniques involving radioisotopes.

4. Establish and sustain procedures for purchasing, receiving and shipping all radioactive materials coming to or leaving Yale.

5. Monitor all University isotope laboratories, accelerators, x-ray machines and other equipment capable of producing ionizing electromagnetic radiation.

6. Distribute and process personnel monitoring devices including film badges and thermoluminescent dosimeters. Document internal and external personnel exposures, and notify individuals of exposures. Recommend appropriate remedial actions for exposures exceeding ALARA investigational levels.

7. Operate Radioisotope Use Facilities: 1138 KBT and B-01 BCMM. These laboratories are equipped for the handling of high levels of activity, and for the performance of iodinations. Space is available in the above laboratories to any authorized Yale investigator on an allocation basis.

8. Store stock solutions containing large quantities of isotopes.

9. Supervise the leak tests of sealed sources and maintain the required records.

10. Maintain a centralized inventory of all radioactive materials at Yale.

11. Provide regulatory oversight of the radioactive waste disposal program of the Environmental Services Section, including the processing, storage and disposal of radioactive waste and maintenance of the required records.

12. Respond to laboratory emergencies involving radioactive materials and/or personnel contamination, and supervise decontamination efforts as needed.

13. Perform decommission surveys on equipment and/or in radioactive material use laboratories, prior to returning them to non-restricted use (i.e. equipment to be repaired or disposed, laboratory renovations or Principal Investigator's leaving current laboratory space and returning the lab to a non-radioactive use facility).

14. Review and process radioisotope use applications submitted by Principal Investigators desiring authorization to use radioactive materials. Make recommendations to the Radiation Safety Committee on the approval of these applications.

15. The Director/Manager of the Radiation Safety Section, serves as the University's Radiation Safety Officer (RSO) for activities conducted under the University's license with the Nuclear Regulatory Commission, and Yale's registration with the State of Connecticut Department of Environmental Protection.

Note: The following excerpt is from the Yale Policy and Procedures Manual and is inserted here for informational purposes.

503 Employee Health and Safety

The University seeks to maintain a work environment in which physical and environmental conditions are such that work-related accidents or illnesses are minimized. To help maintain a safe environment as well as to evaluate and manage those health and safety problems that arise, the University maintains an Office of Environmental Health and Safety which works with the Department of Employee Health of the University Health Services. An employee with a specific concern about a possible health or safety problem should discuss this concern with an immediate supervisor or his or her department business officer. Problems not satisfactorily resolved in this manner should then be referred to the Department of Employee Health or to the Office of Environmental Health and Safety.

AUTHORIZED PRINCIPAL INVESTIGATOR RESPONSIBILITIES

Authorized Principal Investigators are responsible for ensuring that laboratory personnel follow the Individual User Responsibilities listed on page 10. Principal Investigators have the further responsibility to:

1. Plan adequately for experiments and accurately determine the type and quantity of radiation or radioactive material to be used. This determination will generally be a good indication of the safety measures that should be employed. Experimental procedures must be well outlined to allow adequate review of safety precautions at the time of authorization by the Radiation Safety Section and Radiation Safety Committee. Where possible, a cold run using the planned procedures or tracer quantities of radioactive material is recommended to avoid unforeseen safety problems. In any situation where there is an appreciable quantity of radioactive material used which varies from the authorized protocol, Radiation Safety must be consulted before proceeding.

2. Provide specific radiation safety training to those employees for whom they are responsible. Instruct employees in the use of safe techniques and in the application of approved radiation safety practices, and assure that no employee is permitted to work with radioactive materials until he or she has attended a radiation safety orientation seminar presented by the Radiation Safety Section.

3. Provide for direct supervision of inexperienced personnel handling radioactive materials during their initial experiments. Initial experiments by inexperienced personnel should be performed with as minimal amounts of radioactivity as possible.

4. Furnish Radiation Safety with information concerning individuals and activities in their areas, particularly pertinent changes in their personnel rosters. Individuals under the age of 18 ARE NOT PERMITTED to be employed in areas where they may be exposed to radiation. (See page 15 for more information on the use of RAM by minors.)

5. Contact Radiation Safety when:

   a. There are major changes in operational procedures, new techniques, or use of different isotopes;

   b. There are renovations, alterations, or radioactive use equipment maintenance functions that need to be performed by Physical Plant or outside vendors (for example, the removal of a radiochemical fume hood); Note: See Appendix IX: Laboratory and Equipment Decommissioning information;

   c. New operations are anticipated which might lead to personnel exposures;

   d. Changing location, planning long absences from the University or leaving the University.

   e. Contamination is detected on laboratory personnel or their clothing.

f. Yale students under the age of 18 are involved with experiments using radioactive material in approved courses.

6. Comply with the regulations governing the use of radioactive materials as established by the United States Nuclear Regulatory Commission (NRC) and the Yale Radiation Safety Committee. These regulations cover general areas, some of which are mentioned here, which dictate that Principal Investigators:

   a. Use proper procurement and transfer procedures. (See appropriate appendices to this manual);

   b. Follow transportation procedures outlined in Appendix VII. These include, the transport of radioactive materials between areas within Yale, including cross campus transfers involving public streets;

   c. Properly post areas where radioisotopes are stored or used, or where radiation fields may exist;

   d. Secure radioisotopes in their possession from unauthorized use;

   e. Record the receipt, transfer and disposal of radioactive materials in their area. The Principal Investigator should submit radioactive material inventory data on a regular basis as requested by the Radiation Safety Section.

   f. Assure that all radioactive waste materials are handled in accordance with NRC regulations and are transferred properly to the Environmental Services Section for disposal. Comply with Radiation Safety Section requirements pertaining to documentation of all radioactive waste disposal actions within the laboratory. The Principal Investigator is responsible for safe and proper storage of all radioactive waste until it is removed from the laboratory by Environmental Services personnel.

   g. Assure that appropriate records of radioactive waste are maintained and are reported to the Radiation Safety Section as requested.

   h. Provide adequate instrumentation for assessing potential radiation exposures in their area and performing routine surveys of the work area as necessary, and as required. Suggested routine procedures are outlined in Appendix V.

i. Take steps to prevent the transfer of radioactive materials to unauthorized individuals. This includes the proper disposition of radioactive materials possessed by terminating employees and/or students.

j. Ensure the prompt distribution and return of all dosimetry devices (badges) issued by the Radiation Safety Section.

7. Keep all employee exposures to radiation As Low As Reasonably Achievable (ALARA), and specifically below the maximum permissible exposures listed in Table 1.

TABLE 1

NUCLEAR REGULATORY COMMISSION
OCCUPATIONAL EXPOSURE LIMITS*

	YEARLY LIMIT (mrem)
WHOLE BODY	5000
SKIN OF THE WHOLE BODY	50000
EXTREMITY	50000
LENS OF EYE	15000
MINORS (PERSONS UNDER THE AGE OF 18)	500
FETAL EXPOSURE	500/Nine months

*Note: State of Connecticut exposure limits vary slightly. For more information contact the Radiation Safety Section.

8. Keep the stock of stored, radioactive materials to a minimum within laboratory areas. Authorized users should utilize Radiation Safety storage facilities for large quantities of radioactive material not needed in current research.

9. Ensure that service personnel are not permitted to work on equipment, hoods, sinks or vacuum lines in areas where radioactive materials are used, without the presence of a member of the laboratory staff to provide specific information. Contact the Radiation Safety Section prior to allowing Physical Plant or service personnel to work in certain areas such as radioisotope hoods, ductwork, sinks or vacuum lines where radioactive material may be present, or such other areas or equipment that may have significant contamination. See Appendix IX for information on laboratory and equipment decommissioning.

10. Comply with proper procedures for termination of employment or termination of any experiment using radioactive materials. The Principal Investigator must return to the Environmental Services Section all radioactive materials, including waste, assigned to him under the license. An alternative would be to transfer radioactive material to another authorized Principal Investigator with prior approval from the Radiation Safety Section. Particular care should be exercised to see that specialized equipment such as personnel monitoring devices (namely, film badges and TLDs) are returned to Radiation Safety. Exit thyroid scans should also be obtained for ^{125}I users. A final laboratory decommission survey is also necessary prior to leaving the University. Contact Radiation Safety well in advance to schedule a decommission survey. See Appendix IX.

11. Assure that radioactive materials are not transferred within or outside of the University without first notifying Radiation Safety.

12. Inform Radiation Safety of all declared pregnancies as soon as possible. The University's "Policy Regarding the Safe Use of Radioactive Materials by Pregnant Personnel" may be found in Appendix II.

13. Ensure that radioactive material releases to the environment (sewer disposal, airborne releases, etc.) are maintained within current University guidelines.

14. Maintain compliance with University regulations on eating, drinking and smoking restrictions in isotope areas. Prohibit the use of mouth pipettes.

15. Keep lab staff members informed of current radiation safety issues, new policies, and changes in requirements.

16. Familiarize himself/herself and his/her laboratory personnel with the contents of this Radiation Safety Manual.

INDIVIDUAL USER RESPONSIBILITY

Each individual at Yale who has any contact with radioactive materials or radiation producing equipment has the responsibility to:

1. Keep his/her exposure to radiation As Low As Reasonably Achievable (ALARA), and well below the permissible exposures listed previously in Table 1 (page 8).

2. Wear the appropriate personnel monitoring equipment such as film badges, TLDs, or finger rings as prescribed by Radiation Safety. Such dosimetry devices should be returned promptly at the end of each monitoring period and when terminating isotope use or employment.

3. Survey their hands, shoes and body for radioactive contamination <u>before</u> leaving a radioisotope use laboratory. Documentation of these survey results (date, name, and contamination level) is recommended. Upon detecting skin contamination Radiation Safety should be <u>notified immediately:</u> see inside front cover of manual for emergency phone numbers.

4. Use appropriate protective measures when working with radioactive materials. Such recommended measures may include:

    a. Wearing protective clothing (gloves, laboratory coat and eye protection) whenever working with radioisotopes, and leaving such clothing inside the laboratory area. Opened toe shoes should not be worn in isotope laboratories; other apparel may not be appropriate for work with isotopes as well, for example, shorts.

    b. Use appropriate radiation shields. Consult with Radiation Safety for advice concerning appropriate shielding.

    c. Use mechanical devices or remote handling devices when appropriate to reduce exposure to the extremities.

    d. Use automatic or remote pipetting devices. <u>NEVER PIPETTE RADIOACTIVE MATERIALS BY MOUTH!</u>

    e. Perform radioactive work within confines of an approved hood or glove box if it is suspected radioactive material may be released into the air. Some isotope work requires the use of a hood or a glove box.

    f. Perform experiments involving radioisotopes in an efficient, expeditious manner in order to reduce external exposures and the chance of personal contamination.

5. Refrain from eating, drinking and/or smoking in areas where radioactive materials are present. DO NOT STORE FOOD OR BEVERAGES in refrigerators used for storing radioactive materials.

6. Maintain good work habits and safe laboratory techniques. Do not work with radioactive materials without protective gloves. Wear disposable gloves (two pairs when possible) and change them often. Wash hands and arms thoroughly after working with radioactive materials. See Appendix III for laboratory safety procedures, and consult Appendix IV for general safety information and handling precautions for work with radioisotopes.

7. Survey work areas frequently with wipe tests and/or survey meters. Document the date, contamination levels, location of the survey, and name of surveyor. See Appendix V for a Guide to Laboratory Survey Procedures. Any contamination found should be cleaned immediately. Radiation Safety may need to be informed of contamination resulting from accidental spills. Skin contamination should be reported immediately to Radiation Safety.

8. Survey all incoming shipments of radioactive materials for completeness of order and possible contamination. Document the date, name of person performing the survey and survey results. Open all packages on absorbent matting, in a hood (if available), while wearing protective clothing. See Appendix VI for specific details on recommended procedures for handling packages containing radioactive material.

9. Keep the laboratory neat and organized. Radioactive work areas should be free from equipment and materials not required for immediate use. Keep or transport materials in such a manner as to prevent breakage or spillage (double container), and to insure adequate shielding. Keep work surfaces covered with plastic-backed absorbent material, preferably in a tray or pan, to limit and collect spillage in case of accident. Store liquid waste containers in secondary containers.

10. If radioactive material is to be moved between buildings, across campus, or to another institution or facility refer to Appendix VII for the required procedures on transporting and shipping radioactive materials. Radioactive materials must be packaged and shipped according to regulations. There are severe civil and criminal penalties for improper radioactive material transfers.

11. Label and isolate radioactive waste and equipment, such as glassware, used in laboratories for radioactive materials. Once used for radioactive substances, equipment should not be used for non-radioactive work, and should not be permitted to leave the area until demonstrated to be free of contamination.

12. Request Radiation Safety Section clearances before any repair of contaminated equipment in the laboratory by shop personnel or commercial service contractors.

13. Immediately report accidental inhalation, ingestion, skin contamination, or injury involving radioactive materials or personal contamination to the Principal Investigator and the Radiation Safety Section. Carry out recommended corrective measures. Individuals shall cooperate in investigations to evaluate their exposure. (See Appendix XX for proper actions in emergency situations.)

14. Promptly comply with requests from Radiation Safety concerning intake measurements, the submission of bioassay samples, determination of skin contamination levels, and scheduling for requested radiation emergency physical examinations.

15. Contact Radiation Safety immediately after decontamination procedures have been initiated when someone becomes contaminated with radioactive materials. Wash skin area gently with soapy water, or rinse eyes with water, while colleagues are contacting the Radiation Safety Office for advice. Measure activity on contaminated area with lab instrument after initial attempt at removal. During off-hours contact Campus Police (111) for emergencies. Campus Police has contact numbers for Radiation Safety Section personnel.

16. Carry out decontamination procedures when necessary, and take the necessary steps to prevent the spread of contamination to other areas.

17. Notify the Principal Investigator and the Radiation Safety Section of all declared pregnancies as soon as possible. The University's "Policy Regarding the Safe Use of Radioactive Materials by Pregnant Personnel" may be found in Appendix II.

OBTAINING AUTHORIZATION TO USE RADIOACTIVE MATERIALS

As a matter of policy, the person applying for authorization must be a Faculty Member (Professor, Associate Professor, Assistant Professor, Senior Research Scientist or Research Scientist) of Yale University. The Radiation Safety Section (RSS) will furnish application forms and necessary information. The Radiation Safety Section is the only group who may procure radioactive materials at Yale University.

Authorization Procedure

a. To obtain the privilege of ordering radioactive materials for use on Yale property, obtain an application from the Radiation Safety Office (737-2118). These forms must be completed in detail and returned to Radiation Safety. A Health Physicist (HP) from within the RSS will review submitted applications. A meeting will be scheduled between the reviewing HP and the applying PI at which time safety issues and concerns can be addressed. The applications will then undergo review by the Radiation Safety Officer (RSO) and the Yale Radiation Safety Committee (RSC). Once all reviews are finished and approval is granted, the applying PI will be notified and supplied copies of the approved applications. (Note that subcommittee approval is available between RSC meetings in selected cases. Call RSS for more information.) The Radiation Safety Committee's approval of any application will expire 36 months from date of approval. Renewal applications will automatically be reviewed with Principal Investigators prior to each application expiring.

b. For isotopes and uses not covered by the University's license, a Nuclear Regulatory Commission License amendment must be obtained prior to University approval being granted by the Radiation Safety Committee.

c. Human use of radioactive material is not permitted under the terms of the Yale University license. Forms for human use applications may be secured from the Chairman of the Yale-New Haven Hospital Radiation Safety Committee for Y-NHH sponsored human use studies.

The Yale University NRC Broad license (and State of CT DEP registration) authorizes the use of radioactive material for research and development, education and instrument calibration. Our license specifically prohibits the use of licensed material (or the radiations therefrom) in or on human beings. Field applications where radioactivity would be released are also prohibited.

Research and development is defined in 10 CFR 30.4 as:

> (1) Theoretical analysis, exploration, or experimentation; or (2) the extension of investigative findings and theories of a scientific or technical nature into practical application for experimental and demonstration purposes, including the experimental production and testing of models, devices, equipment, materials and processes. “Research and development” as used in this part and parts 31 through 35 does not include the internal or external administration of byproduct material, or the radiation therefrom, to human beings.

PURCHASING OF RADIOACTIVE MATERIAL

After a Principal Investigator has received approval to use radioactive material, orders and other types of receipts of radioactive materials may be placed by telephone with the Radiation Safety Purchasing Assistant, (785-3552). All orders for radioactive material must be placed with Radiation Safety. **Do not place orders directly with vendors or through the Yale Purchasing Department**! When placing an order by telephone with the Radiation Safety Section give the following information:

- Name of authorized Principal Investigator
- Building and room number where the isotope should be delivered
- Name of person placing the order and telephone number
- VIP # (or PTAEO # if VIP # not available)
- Name of vendor, catalog number, chemical name, microcurie or millicurie amount, isotope and any special information or instructions.
- Desired ship date. (Many materials are shipped the same day for receipt the following day)

ALL orders must be approved by the Radiation Safety Section. Orders should be called in between 9:00 AM and 3:00 PM.

The procedure for gratis shipments is the same as for purchases except that there is no financial information for gratis shipments.

RECEIPT OF ISOTOPES

When an isotope is received at an appropriate University receiving room, the Radiation Safety Section is immediately notified.

The Radiation Safety Section will monitor those packages labeled as containing radioactive material, in accordance with applicable regulations. Packages, however, will not be opened by Radiation Safety Section personnel. A recommended procedure for opening packages containing radioactive materials can be found in Appendix VI.

Packages will then be delivered to the location specified at the time the order was placed. Please anticipate the arrival of packages and have authorized radioactive material users present in the lab to sign for and accept receipt of these materials. Authorized radioactive material users may sign for radioactive packages only after they have attended a Radiation Safety Orientation seminar and have been trained in package receipt procedures.

MINORS IN YALE UNIVERSITY LABORATORIES

1. No person under the age of 16 may enter a Yale biology, chemistry, physics, or medical research laboratory unless they are participating in an organized educational program sponsored by their school or municipality. The program must be approved by the dean of the Yale school where the program will take place, the Office of Environmental Health and Safety, and the Office of the New Haven Affairs.

2. No person between the ages of 16 and 18 may enter a Yale biology, chemistry, physics, or medical research laboratory except:

   a. As part of a group or individual educational program approved by the dean of the school where the program will take place and the Office of Environmental Health and Safety.

   OR

   b. As part of a relationship in which a Yale faculty member or researcher is acting as a mentor to a young person, the young person will not be present in a Yale laboratory for more than five hours a week, and the young person's activities in the laboratory have been approved by the Office of Environmental Health and Safety

3. All persons under the age of 18 who enter a Yale biology, chemistry, physics, or medical research laboratory must complete all required safety training and adhere to all restrictions imposed by the Office of Environmental Health and Safety.

4. Participants in the educational and mentoring programs described in 2a and b may not be paid according to an hourly, weekly, or monthly rate, but they may receive a lump-sum stipend approved, in advance, by the Department of Human Resource Services. Persons under the age of 16 may not receive any type of payment in connection with their presence in a Yale biology, chemistry, physics, or medical research laboratory.

5. Yale faculty members sponsoring minors shall be responsible for obtaining all authorizations required under these rules

TRAINING OF NEW EMPLOYEES AND INDIVIDUALS WITH NO PREVIOUS RADIATION WORK EXPERIENCE AT YALE UNIVERSITY

Each individual working in, or frequenting a radioactive material use area at Yale University should be provided information on any potential radiation hazards present in the area, the biological effects of radiation and radiation protection techniques. Each authorized Principal Investigator is responsible for training the individuals working in his/her laboratory. This training should include instruction on specific techniques incorporated during the performance of radioactive materials experiments and the application of approved radiation safety practices. Direct supervision of inexperienced personnel during their initial experiments should also be provided by the authorized Principal Investigator, or his/her designee. The Radiation Safety Section assists Principal Investigators by providing orientation seminars on radiation safety and radiation protection techniques. Individuals should not work with radioactive materials until they have attended a Radiation Safety Orientation seminar, presented by the Radiation Safety Section. These seminars are offered at least two times each month. Principal Investigators are kept informed of the upcoming schedule for orientation seminars. Additional optional lectures on topics of interest are also provided by the Radiation Safety Section. Call 737-2140 for information on Radiation Safety Training.

PERSONNEL DOSIMETRY

It is the intent of the Radiation Safety Committee to maintain occupational radiation exposures to Yale faculty, staff, and students to a minimum. To assist in this effort, the following methods of personnel monitoring are employed:

1. Dosimetry Badges

   A number of devices are available for measuring employees' external exposures. These devices include monthly film badges, quarterly thermoluminescent dosimeters (TLD) and finger rings. Requests for monitors should be submitted to Radiation Safety using the form on page 19. Anyone directly involved with handling larger amounts of radioactive materials, or ionizing radiation producing equipment at University facilities may be required to have and wear a film badge or TLD when working. Monitoring devices will not be issued to those individuals handling only low energy beta emitters (^{3}H, ^{14}C, ^{35}S and ^{33}P) or pure alpha emitters. Finger ring radiation monitors are required when handling 10 mCi or more of ^{32}P, and in other situations where hand exposures may be significant. Finger rings should be requested from Radiation Safety when needed. Changes or cancellations to the radiation monitors used in the laboratory can be made by using the form on page 21.

2. Urine Bioassays

The Radiation Safety Section is equipped to analyze urine samples for radioactivity. Individuals involved in operations which utilize tritium in a form other than a sealed source or metallic foil, in amounts of 100 millicuries or greater, should submit urine samples for analysis. The samples submitted should be taken 24 hours after a single experiment. For continuing experiments, samples may be required at weekly intervals. Arrangements for this service should be made through the Radiation Safety Section. Bioassays may be requested by the Radiation Safety Section for individuals using isotopes other than tritium or as follow-up to unusual situations and spills. A woman may decide or be asked to submit a background urine sample when a pregnancy is declared.

3. Thyroid Counts

The Radiation Safety Section maintains a thyroid monitoring program to identify and quantify any personnel uptakes of radioiodine. Individuals working with significant quantities of radioactive iodine should have thyroid counts on a frequency established by the Radiation Safety Section. Thyroid counts are required for all individuals performing iodinations both before, and 6 to 72 hours after, an iodination is performed. Quarterly counts may be required for individuals who work with iodine but do not actually perform iodinations. Thyroid monitoring is offered every workday morning, Monday through Friday, between the hours of 9:00 AM to 10:00 AM, in room B-01 BCMM. Appointments are not required. If there is an accident or spill involving radioactive iodine, contact Radiation Safety for monitoring the potential thyroid uptake. In some cases, women with confirmed pregnancies may decide, or be required, to have a background thyroid count and periodic counts for the duration of gestation. Please contact Radiation Safety at 785-4250 for further information on thyroid monitoring, or to resolve scheduling conflicts.

Forms and Guidelines

To apply for radiation monitoring at Yale University (not to include Yale New Haven Hospital or the VA Hospital) the following form must be completed and returned to the Radiation Safety Office at:

Attn: Radiation Monitoring Service
135 College Street
New Haven, CT 06510
or
Fax #: 785-7588

Be certain to complete all sections of the form (especially page 2 Previous Dose History information) or it may delay processing.

General Guidelines for Proper Use of Personnel Monitoring Devices:

- *Wear the badge only when working at Yale University*
- *Wear only your own badge - i.e. check the name*
- *Wear the badge outside any protective clothing*
- *Do not remove the badge from its holder*
- *Store the badge in a cool, dry place away from sources of radiation when it is not being worn (do not expose badges to chemicals or heat)*
- *Submit the badge for processing by the 10th of the month after your new badge is provided*
- *Report loss or damage of badge promptly so that a replacement may be issued*
- *When transferring to another lab where you will be using radioactive material, take your badge with you, then call the Radiation Safety Section with the new lab information.*

If you have any questions about personnel monitoring, call the Radiation Safety Section at 737-2101 or 737-2142.

YALE UNIVERSITY

REQUEST FOR RADIATION MONITORS

Please Print or Type

Date:______________________________

Name:____
last first middle initial

Social Security #: _______________________ Date of Birth: ______________ Sex: ___________

Title: _________________________________ Phone at Yale: ___________________________

Authorized Principal Investigator:____

Department:____

Type of radioactive material and/or radiation producing equipment you will be involved with:

____

RADIATION MONITORS ARE NOT REQUIRED FOR WORK WITH C-14, H-3, S-35 & P-33

Date badge will be needed:____

How long will badge service be needed: ____

Have you attended a Radiation Safety Seminar at Yale? Yes ________________ No ____________

If yes, please give approximate date: ____

Have you ever: (a) been issued a badge at Yale before? Yes _______ Year _______ No__________

(b) been monitored at another institution for exposure to radiation? Yes __________ No ________

If answer to (b) above is "yes", please complete (page 2) of this form.

Your Signature:____

By signing above and accepting a radiation monitor from Yale University, the RSS has your permission to acquire all exposure information from other current employers, if you are exposed at more that one place of employment.

Return completed form to: Attn: Radiation Monitoring Service
135 College Street, New Haven, CT 06510

OFFICE USE ONLY
PI Verified:_________________________ Seminar Date Verified:______________________
Spare Badge #:____________ Binary #:_________________________ Series: ____________
Date:____________________ Type:____________________________ Period:____________
Participant #:______________ Entered:_________________ Sent to Landauer:____________

YALE UNIVERSITY REQUEST FOR RADIATION MONITORS - PAGE 2
Personal Radiation Exposure History
Please Print or Type

Complete a separate block for each institution that has or is currently monitoring you for radiation exposure.

INSTITUTION:____

DEPARTMENT/SUPERVISOR: ________________________________

STREET ADDRESS: ____________________________________

CITY, STATE, ZIP: ____________________________________

DATES AT INSTITUTION: FROM:______________ TO: __________________

ADDITIONAL INFORMATION:_________________________________

I authorize the release of past radiation exposure information to Yale University.

Signature:____

INSTITUTION:____

DEPARTMENT/SUPERVISOR: ________________________________

STREET ADDRESS: ____________________________________

CITY, STATE, ZIP: ____________________________________

DATES AT INSTITUTION: FROM:______________ TO: __________________

ADDITIONAL INFORMATION:_________________________________

I authorize the release of past radiation exposure information to Yale University.

Signature:____

INSTITUTION:____

DEPARTMENT/SUPERVISOR: ________________________________

STREET ADDRESS: ____________________________________

CITY, STATE, ZIP: ____________________________________

DATES AT INSTITUTION: FROM:______________ TO: __________________

ADDITIONAL INFORMATION:_________________________________

I authorize the release of past radiation exposure information to Yale University.

Signature:____

RADIATION MONITORING SERVICE - YALE UNIVERSITY
CHANGES/CANCELLATIONS

Please Print or Type

Do not use this form to request new badge service.

Date: ________________________________

Badge #: ____________________________ Social Security #: ____________________________
(Numbers below date on badge or above name on ring)

Name: ____
last first middle initial

Authorized Principal Investigator: ____

Type of Change: ____

_____ Cancel Badge: Type: _____________________ Effective date: _____________________

_____ Department Change: New Department: ____

Authorized Principal Investigator: ____________________________

_____ Name Change: New name:____

_____ Change/Add Type of Badge: Whole Body _________________ Finger _______________

_____ Reactivate: Effective date: ____

_____ Issue Spare Badge: Reason: ____

Your Signature:____

Return completed form to: Attn: Radiation Monitoring Service
135 College Street, New Haven, CT 06510

Questions?? Call 737-2101

OFFICE USE ONLY
Spare Badge #:______________ Binary #:___________________ Series:_____________
Date:______________________ Type:_____________________ Period:_____________
Participant #:________________ Entered:__________Sent to Landauer:_____________

Delete from authorization program?: ❑ Yes ❑ No

Comments: ____

RADIOACTIVE WASTE DISPOSAL

The United States Nuclear Regulatory Commission (NRC) requires that all licensees maintain written records regarding disposal of radioactive waste. In order for the University to meet these requirements, individual Principal Investigators are required to complete and keep records. On a routine basis a form will be sent to Principal Investigators in order that they may supply Radiation Safety with a summary of the following information:

Names of isotopes and quantities on hand (mCi)
Activities (mCi) of waste
Activities disposed through the sanitary sewer
Special information as necessary

Radiation Safety will compile the appropriate records from the information supplied by the Principal Investigators for the NRC and state inspections. Each authorized Principal Investigator is responsible for the secure and safe storage of radioactive waste generated. This generally means storage within the individual's laboratory. In addition, shielding and potential for volatility, must be considered by the Principal Investigator. Secondary containers such as plastic basins are useful and recommended for storage of liquid waste. See Appendix VIII for Radioactive Waste Packaging and Disposal Procedures.

Some liquid scintillation counting solutions present a unique disposal problem when contaminated with radioactive material. Many liquid scintillation cocktails are not approved for use at Yale. Only the following fluors are currently approved for use at Yale University:

BetaMax	CytoScint ES	Safescint	Ultima Flo
Ecolite	Ecolume	ReadySafe	Universol ES
Ecoscint	Optifluor	Ultima Gold	

ARRANGING FOR A RADIOACTIVE WASTE PICKUP

1. Complete a radioactive waste removal tag for each container needing to be removed from the lab. Call the Environmental Services Section at 785-3551 to request a waste pickup. Anticipate at least two business days between the waste call and actual removal of the waste containers. Replacement containers will be provided at time of pickup.
2. Supply the following information when calling in waste:
    - a. The PI's name, caller's name and phone number.
    - b. The Tag number for each container, and the type, and location of each container to be picked up.
    - c. The isotope and amount (in mCi) of each radioactive material present in each container.
3. For liquid waste, in addition to the above, please furnish:
    - a. The chemical form of the solvent(s), including approximate percentages. For example: Water (90%), Ethanol (10%).
    - b. The pH of the liquid waste. Should be between 5.5 and 9.5.
4. For radioactively contaminated animals, please furnish:
    - a. The number and types of animals--CARCASSES MUST BE FROZEN.
    - b. The isotope and quantity present in each animal.
    - c. Information regarding the presence of any PVC (polyvinyl chloride) or Stainless Steel implants.

<u>Please note that the following conditions may result in the waste not being removed from the laboratory:</u>

- a. Isotope and/or the amount present (in mCi) not indicated or provided.
- b. Incomplete information on the pickup request form or waste tag.
- c. Overflowing or leaking containers.
- d. Significant removable contamination.
- e. Needles or other unprotected sharps in the dry waste container.
- f. Animals that are not wrapped and/or frozen, or animals which are frozen to freezer surface.
- g. Liquid waste in a dry waste box.
- h. Waste containing active infectious agents.
- i. Lead in a dry waste box.
- j. Any other violations of waste disposal procedures as outlined in Appendix VIII of this manual.

5. Please see Appendix VIII for more detailed information on waste disposal policies. The information outlined in this appendix is the current radioactive waste packaging and disposal policy for Yale University. These procedures may be revised in the future depending on changing regulations.

GLOSSARY OF TERMS

ALARA - All radiation doses shall be maintained As Low As Reasonably Achievable, economical and social factors taken into consideration. See Appendix I for Yale's ALARA program.

Annual Limit of Intake (ALI) - Derived limit for the amount of radioactive material taken into the body by inhalation or ingestion in a year.

Becquerel (Bq) - SI unit for quantity or activity of radioactive material. Equal to 1 disintegration per second.

Bioassay - The process by which samples of body excreta are analyzed for the presence of radioactivity. A bioassay may also be a direct count of a body organ, such as is conducted during a thyroid count.

Committed Dose Equivalent (CDE)- The dose equivalent to organs or tissues of reference that will be received from an intake of radioactive material by an individual during the 50 year period following the intake.

Committed Effective Dose Equivalent (CEDE) - The sum of the products of the weighting factors applicable to each of the body organs or tissues that are irradiated and the committed dose equivalent to these organs or tissues.

Contamination - Radioactive material in any place it is not desired. Contamination may or may not be removed from a surface by touching it. It is similar to dust but it cannot be seen.

Cpm (Counts per minute) - Radiation which enters a detector and is registered by the electronic system as interactions per minute in the detector.

Curie (Ci) - Unit of activity. A measure of the amount of radioactivity present. One curie equals 3.7E+10 disintegrations per second. (37,000,000,000 disintegrations per second).

Declared Pregnancy - When a woman voluntarily informs her employer in writing of her pregnancy and the estimated date of conception. See Appendix II for Yale's policy regarding the safe use of radioactive material by pregnant personnel.

Decontaminate (Decon) - The action by which radioactive contamination is removed from a surface, device, piece of equipment, or from a body surface.

Deep Dose Equivalent (DDE) - The dose equivalent at a tissue depth of 1 cm.

Derived Air Concentration (DAC) - The concentration of a given radionuclide in air which, when inhaled by the reference man for a working year of 2000 hours results in an intake of one ALI.

D.O.T. - The United States Department of Transportation. This federal agency regulates the transportation of radioactive and other hazardous materials. The regulations of this agency require very specific handling and packaging of radioactive materials when transported on any public street or vehicle. Note: There is also a State of Connecticut D.O.T.

Effective Dose Equivalent (EDE) - The sum of the products of the dose equivalent to the organ or tissue and the weighting factors applicable to each of the body organs or tissues that are irradiated.

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

Eye Dose Equivalent (LDE) - The external exposure of the lens of the eye taken as the dose equivalent at a tissue depth of 0.3 cm.

Film Badge - A device containing x-ray film which measures an individual's cumulative dose to penetrating radiation (Energy > 200 kev) from sources outside the body.

Gray - SI Unit of absorbed dose, 1 Gray = 100 rad.

Half-life - Time required for a radioactive substance to lose 50% of its activity by decay. Each radionuclide has a unique half-life.

Health Physics - The profession dedicated to the practice of radiation safety. At Yale this organization of professionals is the Radiation Safety Section.

Intake - Radioactive material which enters the body.

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

Iodination - The process by which various organic compounds are labeled with radioactive iodine, usually ^{125}I. Large amounts of radioactive iodine may be liberated during such procedures and escape to the air. Special facilities are therefore required for such procedures.

Laser - A device which produces a narrow beam of very intense radiation usually in the visible light region of the electro-magnetic spectrum. The primary hazard of such radiation is exposure of the eyes.

Microcurie (uCi) - 1/1,000,000 of a curie. One uCi = 37,000 disintegrations per second.

Microwave - A type of radiation in the radio frequency range which interacts with the body primarily by heating body tissues. Depending on the frequency this may be surface heating or deep heating.

Millicurie (mCi) - 1/1000th of a curie. One mCi = 37,000,000 disintegrations per second.

Millirem (mrem) - Unit of radiation dose equivalent. 1/1000th of a rem. 1 rem = 1000 mrem.

Monitoring - Periodic or continuous determination of the amount of ionizing radiation or radioactive contamination present. See also; Personnel Monitoring

Occupational Exposure - A radiation exposure resulting from one's work with radioactive material or devices which produce radiation. This type of exposure only includes the radiation one is exposed to while at work.

Pancake Probe - A Geiger-Mueller tube with a pancake-like window used primarily for the detection of beta radiation. It is useful because of its excellent sensitivity to beta particles, except those produced by isotopes such as ^{3}H tritium.

Personnel Monitoring - Monitoring any part of an individual, their breath, or excretions, or any portion of their clothing.

Rad - Unit of absorbed dose. Equal to 0.01J/Kg in any medium.

Radiation Safety Section (RSS) - At Yale, the organization of radiation safety professionals and technical personnel responsible for radiation safety related issues.

Radiation Safety Officer (RSO) - The individual identified by the Nuclear Regulatory Commission (NRC) as the individual responsible to the Licensee and the NRC for implementation of radiation safety programs by the Licensee. At Yale University this responsibility is assigned by the University Radiation Safety Committee to the Director/Manager, Radiation Safety Section.

Range - The maximum distance the radiation from a radioactive source will travel. Generally used for beta and alpha radiation.

Reference Man - A hypothetical aggregation of human physical and physiological characteristics arrived at by international consensus. These characteristics may be used by researchers and public health workers to standardize results of experiments and to relate biological insult to a common base.

Rem - A special unit of dose equivalent. The dose equivalent in rems is numerically equal to the absorbed dose in rads multiplied by the quality factor. (Relates to biological effects)

Sealed Source - A radioactive source which is "encapsulated" such that normal and accidental stress on the capsule will not release the radioactive material.

Shallow Dose Equivalent - The dose equivalent at a tissue depth of 0.007 cm averaged over an area of 1 cm^2.

Shielding - Material placed between a radiation source and your body or extremities to absorb the radiation.

Sievert (Sv) - SI unit of dose equivalent, 1 sievert = 100 rem.

Stock Solution - A highly concentrated amount of radioactive material.

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

Thyroid Count - Placing a radiation detector adjacent to one's neck in order to determine the amount of radioactive iodine present in an individual's thyroid gland.

U.S.N.R.C or N.R.C. - The United States Nuclear Regulatory Commission, the federal agency which regulates the use of radioactive material in the United States. Yale holds 3 licenses with this agency and is subject to its authority.

Uptake - Radioactive material which upon entering the body stays in the body.

Urinalysis - The collection of a urine specimen and the subsequent analysis for the presence of radioactivity. It is a measure of the amount of radioactive isotope present in the body.

Weighted Committed Dose Equivalent - The product of the committed dose equivalent to an organ and the weighting factor applicable to the organ.

Weighting Factor - The proportion of the risk of effects resulting from irradiation of an organ or tissue to the total risk of effects when the whole body is irradiated uniformly.

Wipe Test - A test for the amount of removable radioactivity on a surface. This test is done by wiping a filter paper on a surface and analyzing it in a radiation counter.

APPENDICES

APPENDIX - I ALARA PROGRAM

1. **Management Commitment**

   a. We, the administration of Yale University, are committed to the program described herein for keeping individual and collective doses from ionizing radiation as low as is reasonably achievable (ALARA). In accord 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 an annual review of the radiation safety program, including ALARA considerations. This will include reviews of operating procedures and past dose records, inspections, and consultations with the Radiation Safety Section staff.

   c. Modifications to research protocols, maintenance procedures and to equipment and facilities will be made if they will reduce exposures unless the burden, in our judgment, outweighs the potential for dose reduction. 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 radiological design modifications have been recommended but not implemented, we will be prepared to describe the reasons for not implementing them.

   d. The goal of the program is to maintain doses to individuals and releases to environment as far below the limits as is reasonably achievable. The sum of the doses received by all exposed individuals will also be maintained at the lowest practicable level consistent with an expanding research program.

2. **Radiation Safety Committee**

   a. Review of Proposed Users and Uses

      (1) During the authorization approval process the RSC will 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 maintain exposure ALARA.

      (2) The RSC will ensure that the users document their procedures and will review the efforts of the applicants to maintain exposure ALARA.

(3) The RSC will review incidents, accidents and results of hazard evaluations as well as corrective actions taken.

b. Delegation of Authority

(1) The University will delegate authority to the RSO for management of the ALARA concept.

(2) A technically qualified staff of Health Physicists, reporting to the RSO, conducts inspections, hazard evaluations and interviews to make recommendations that will include radiological planning which will contribute to dose reduction. The Health Physicists are available for consultation with scientists and other involved university personnel concerning laboratory design, appropriateness of methods and alternatives. The Health Physicists, representing the RSO, have the authority to prevent unsafe practices and stop work if necessary.

(3) A technically qualified staff of Health Physics Technologists, representing the RSO, performs facility and laboratory radiation surveys and inspects facilities to enhance contamination control and reduction of radiation exposure. The Health Physics Technologists, representing the RSO, have the authority to stop work if necessary when specific unsafe practices are identified.

(4) 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 its meetings.

c. Review of ALARA Program

(1) During the authorization approval process the RSO will encourage all users to review procedures and develop new or revised procedures as appropriate to implement the ALARA concept.

(2) The RSO, or his/her delegated senior staff, will review the exposure records on at least a quarterly basis and initiate investigations where indicated.

(3) The RSC will perform an annual review of occupational radiation exposures. The principal purpose of this review is to assess trends in occupational exposure as an index of the ALARA program quality.

(4) The RSC will evaluate Yale's overall efforts for maintaining doses ALARA on an annual basis. This review will include the efforts of the RSO, authorized users and ancillary groups as well as those of the administration.

3. **Radiation Safety Officer**

a. Reviews

(1) Review records of radiation surveys. The RSO [or Assistant RSO] will review radiation surveys to determine that dose rates, amounts of contamination, and releases to the environment were at ALARA levels during the previous quarter.

(2) Annual Review of occupational exposures. The RSO [or Assistant RSO] will review at least annually the 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.

(3) Annual review of the radiation safety program. The RSO will perform an annual review of the radiation safety program for consistency with the ALARA philosophy.

b. Educational Responsibilities for ALARA Program

(1) The staff of the Radiation Safety Section will inform authorized users of ALARA program efforts in its educational and training sessions.

(2) The staff of the Radiation Safety Section will ensure that authorized users 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. 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 staff of the Radiation Safety Section will be in close contact with Principal Investigators and authorized users in order to develop ALARA procedures for working with radioactive materials.

(2) The RSO will establish procedures for receiving and evaluating the suggestions of individual radiation users for improving health physics practices and will encourage the use of those procedures when deemed appropriate.

d. Reviewing Instances of Deviation from ALARA philosophy.

The RSO [or Assistant RSO] will initiate investigations of all known instances of deviation from the ALARA philosophy and, if possible, will determine the causes. When the cause is known, the RSO will implement changes in the program to maintain doses ALARA.

4. **Authorized Users**

a. Principal Investigators will apply to the RSC for authorization to use radioactive materials.

b. Principal Investigators responsibility to supervised individuals

(1) The Principal Investigators will explain the ALARA concept and the need to maintain exposures ALARA to all supervised individuals.

(2) The Principal Investigators 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.

(3) The Principal Investigator is accountable for radiation protection practices in his/her laboratories.

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

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

b. Individuals will be responsible for obeying all safety requirements and reporting any problems to his/her supervisor.

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

Yale has established investigational levels for radiation doses and releases to the environment which, when exceeded, will initiate review or investigation by the RSC and/or the RSO. The investigational levels that Yale has adopted are listed in Table 1. These levels are based on fractions of the exposure limits. These levels apply to both internal and external exposure of individuals (except for pregnant workers).

The RSO [or Assistant RSO] will review and record results of personnel monitoring. The following actions will be taken at the investigational levels as stated in Table 1:

a. Personnel dose less than Investigational Level

Except when deemed appropriate by the RSO, no further action will be taken in those cases where an individuals' dose is less than Table 1 values for the Investigational Level.

b. Personnel dose equal to or greater than Investigational Level

The RSO will investigate in a timely manner the causes of all personnel doses equaling or exceeding Investigational Level and, if warranted, will take action. A report of the investigation, any actions taken, and a copy of the individual's exposure history will be presented to the RSC. The details of these reports will be included in the RSC minutes without identifying the specific individual.

c. Re-establishment of Investigational Level

The RSC may, if appropriate, raise or lower the investigational levels to achieve a desirable level of review. Justification for new investigational levels will be documented. The RSC will review the justification for and must approve or disapprove all revisions of Investigational Levels.

Table 1

Yale University
Radiation Safety Section
Investigational Levels

Organ	Exposure Limit mRem/yr.	Investigational Levels mRem/monitoring period	Cumulative Levels mRem
Whole Body	5000	100	300
Eye	15000	300	900
Skin and/or Extremity	50000	1000	3000
Minors - Under 18 Years of Age (Whole Body)	500	20	30
Embryo/Fetus	500/9 months	20	30
Member of Public	10 mRem constraint level for air emissions 100 mRem/year (Whole Body)	10% of 10 CFR Part20.2003(a)(4) limits	20% of 10 CFR Part20.2003(a)(4) Limits
Environment	Sewer Disposal Releases to Environment	10% of Appendix B Table 3 10% of any limit	

APPENDIX - II INFORMATION FOR OCCUPATIONALLY EXPOSED WOMEN OF CHILDBEARING AGE

In 1994 the U.S. Nuclear Regulatory Commission (NRC) established a dose limit for the embryo/fetus of pregnant radiation workers of 0.5 rem over the entire gestation period. In supporting this dose limit, Yale University developed and instituted a written policy regarding the safe use of radioactive material by pregnant personnel. A copy of this policy follows. Please review the current policy and direct any questions or information requests to Radiation Safety at 737-2140, or 737-2142.

Since many pregnancies are not identified or confirmed until well into the first trimester (the first three months of pregnancy), women of childbearing age planning a pregnancy and working with radioactive materials should practice "ALARA". That is, exposures to radioactive materials should be maintained "As Low As Reasonably Achievable". Rigorous adherence to radiation safety procedures should minimize risks to the fetus and the mother. Call the Radiation Safety Section at 737-2140 or 737-2142 for more information.

YALE UNIVERSITY

Policy Regarding the Safe Use of Radioactive Material by Pregnant Personnel

Yale University strives to keep the radiation exposure of every employee as low as practicable. The United States Nuclear Regulatory Commission (NRC) has an established basic exposure limit of 5 rems per year for all occupationally exposed adults. No clinical evidence of harm would be expected in an adult receiving this dose every year over a working lifetime. In the past, all Yale employees' exposures have been well below the 5 rem/year whole body exposure limit. In fact, in 1998 all whole body external exposures for radiation workers at Yale were below 0.5 rem/year or ten percent of the exposure limit and the majority of workers receive less than 10 mrem/year.

The developing fetus may be more sensitive to radiation than adults. Therefore, the National Council on Radiation Protection and Measurements (NCRP) has recommended that fetal radiation dose as a result of occupational exposure of the mother should not exceed 0.5 rem during the entire gestation period. The Nuclear Regulatory Commission concurs with this recommendation and therefore enacted the separate exposure limit for the embryo/fetus. According to NRC regulations, "The limit for the embryo/fetus of a declared pregnant woman is 0.5 rem over the entire gestation period." [1] The NRC defines a declared pregnant woman as "a woman who has voluntarily informed her employer in writing of her pregnancy and the estimated date of conception." [2] To help ensure the safety of the pregnant woman and her fetus, the Radiation Safety Section is staffed with professionals who can assist pregnant women in evaluating their work requirements and exposure conditions. All pregnant women working with radioactive materials, or frequenting laboratories where radioactive materials are used, are encouraged to contact the Radiation Safety Section for more information.

When a pregnancy is made known to the Radiation Safety Section, a Health Physicist will review which radiation sources are approved for use in the woman's laboratory. The radiation exposure history of the worker will also be reviewed. If the review determines that iodinations are done in the laboratory or that high activity sealed sources and/or x-ray equipment are in use, the worker will be consulted. Recommendations will then be made on an individual basis.

According to Federal regulations, "It is the fundamental responsibility of the pregnant worker to decide when or whether she will formally declare her condition to her employer." [1] If a woman chooses not to declare her pregnancy, Yale University is not required under the regulations to limit her dose to the 0.5 rem limit. However, "undeclared pregnant women are protected under the NRC regulations for all workers." [1] The normal occupational dose limit of 5 rem/year would still be in effect, and the woman's dose would also have to be maintained as low as is reasonably achievable (ALARA). Any woman who has questions or concerns about declaring her pregnancy is strongly encouraged to contact the Radiation Safety Section for a confidential discussion of this issue.

A provision does exist in the regulations so that an additional small incremental dose of 0.05 rem is available. This additional dose provides a "means of ensuring continued employment for the woman, and also removes the threat of inadvertent noncompliance."[1] "The 0.05 rem dose increment is available as an additional dose if the embryo\fetal dose at the time of declaration is greater than 0.45 rem."[1]

The records required to be maintained under this policy will be protected from public disclosure because of their personal privacy nature. Yale University is required to maintain the records of dose to the embryo/fetus, with the records of dose to the declared pregnant woman. To assist the woman in declaring her pregnancy, the form on the next page may be used to notify both the Principal Investigator and the Radiation Safety Section of a pregnancy. Notification will assist the Radiation Safety Section in dose assessment and evaluation, and in making possible safety recommendations.

Any individual having questions related to the radiation protection of the embryo/fetus is encouraged to contact the Radiation Safety Section. NRC Regulatory Guide 8.13, "Instruction Concerning Prenatal Radiation Exposure" and it's Appendix, "Questions and Answers Concerning Prenatal Radiation Exposure" are available to all persons at Yale who work with or frequent laboratories using radioactive materials or radiation producing devices. Please contact the Radiation Safety Section, 135 College Street, for copies.

1 Federal Register, Volume 56, No. 98, Tuesday, May 21, 1991, Rules and Regulations.

2 Code of Federal Regulations, Standards for Protection Against Radiation - 10 CFR 20.1003

CONFIDENTIAL

YALE UNIVERSITY
Notification of Declared Pregnancy

DATE:____

TO:____
Principal Investigator

DEPARTMENT: ____

FROM:____

SOC. SEC.#:____

ADDRESS:____

SIGNATURE:____

I have completed and submitted this form to inform you that I am pregnant. The estimated date of conception* was on or about ______________________ (month/year). I understand that the exposure limit for the embryo/fetus is 0.5 rem for the entire gestation period.

I also understand that meeting the lower dose limit may require a change in job or job responsibilities during my pregnancy.

Please check one of the following:

_______ I have questions related to the radiation protection of the embryo/fetus and would like a professional from the Radiation Safety Section to contact me at:

____
Home or Work Phone Number

_______ If I have questions related to the radiation protection of the embryo/fetus, I will contact the Radiation Safety Section at 737-2140, or 737-2142.

CC: Agnes Barlow, RSO
Office of Environmental Health and Safety
135 College Street

* The NRC defines a declared pregnant woman as "a woman who has voluntarily informed her employer in writing of her pregnancy and the estimated date of conception." Only the month and year need be provided.

Note that you may “undeclare” your pregnancy by notifying the Radiation Safety Section.

If the declaration is not withdrawn, it will be considered expired one year after submission.

APPENDIX - III LABORATORY SAFETY PROCEDURES

Work Surfaces

All radioactive work areas (bench tops, hoods, floors, etc.) as well as storage areas adjacent to permanent set-ups and sinks should be covered at all times with absorbent matting, trays, or other impervious materials. If absorbent matting is used, it should be discarded frequently into approved radioactive waste containers to prevent spread of contamination. Note: Absorbent matting must be used with the absorbent side up. Work areas should be clearly labeled with "Caution Radioactive Material" tape.

Periodic Surveys of Radiation Work Areas

The immediate areas (namely hoods, bench tops and storage areas) in which radioactive materials are being used should be checked for contamination periodically by the authorized users of radioactive materials in each laboratory. In addition, these areas should be inspected each and every time there is reason to suspect a contamination incident. See Appendix V for a guide to performing surveys.

Radioactive Contamination of Areas

In general, radioactive contamination should not be tolerated. Exceptions are active work areas which are clearly marked with the standard radiation caution signs or tape. The Radiation Safety Section may supervise the decontamination of such areas or equipment. The Radiation Safety Section considers 100 counts per minute (above background) of removable contamination as counted on a wipe test in a liquid scintillation counter to be a general guideline for determining the level of contamination requiring cleanup.

Decontamination of Areas Contaminated with Radioactivity

Preparations for decontamination should begin promptly. Determine the extent of the contamination. The Radiation Safety Section may assist in this evaluation. The individual(s) responsible for the contamination will perform the clean-up under the supervision of Radiation Safety personnel. The area or equipment should be considered contaminated until proven otherwise. See Appendix IX for laboratory and equipment decommissioning information, and Appendix V for a guide to conducting laboratory surveys.

Decontamination of Personnel Contaminated with Radioactivity

In all cases of personal contamination notify Radiation Safety immediately. Radioisotope contamination directly on the skin can result in high doses to the skin and requires prompt attention. When an accident or spill occurs, try to decontaminate yourself immediately and carefully. Mild soap and water should be used to initiate this process. Do not abrade or redden the skin, or spread the contamination. Call Radiation Safety (785-3555) at the first available moment after initial decontamination efforts. It is preferred that another member of the laboratory contact the Radiation Safety Section while personnel decontamination efforts continue.

Aerosols, Dusts and Gaseous Products

Procedures involving aerosols, dusts and gaseous products, or procedures which might produce airborne contamination should be conducted in a hood, glove box or other suitable closed system. All releases from such systems should not exceed the Derived Air Concentration (DAC) for the nuclide in question. However, where practical, traps should be incorporated in the experimental set-up to insure that environmental releases are as low as possible. Radioactive gases or materials with radioactive gaseous daughters must be stored in gas-tight containers and must be kept in areas having approved ventilation. Hoods to be used for radioisotope work should be tested by the Office of Environmental Health and Safety to ensure that they meet the minimum requirements for air velocity at the face of the hood.

Iodinations

Procedures in which volatile iodine may be released (iodinations) should be conducted in a glove box or isotope hood with adequate flow rate and charcoal filters. Advice should be sought from the Radiation Safety Section prior to conducting experiments with iodine and the facilities should be evaluated for containment purposes. Iodinations must be performed in approved enclosures with appropriate air sampling devices in place. The Radiation Safety Section maintains iodination facilities which may be used by any approved Principal Investigator and his/her staff. To schedule an iodination in these facilities, please use the telephone numbers listed below.

Facility	Telephone
BO1-BCMM	737-2139/785-4250
1138 KBT	737-2139/785-4250

APPENDIX - IV GENERAL SAFETY INFORMATION AND HANDLING PRECAUTIONS FOR WORK WITH RADIOISOTOPES

The following general safety precautions should be taken whenever working with isotopes. These precautions include but are not limited to:

1. Wear protective clothing when using radioactivity. Laboratory coats, disposable gloves and safety glasses should be worn. Two pairs of gloves are recommended when feasible. Remove protective clothing when leaving the laboratory.

2. Change gloves frequently. Assume gloves are contaminated until proven otherwise. Do not leave laboratory or touch other items with gloves on.

3. Label and prepare areas for handling radioisotopes. Clearly label all containers which will hold radioactive material. Indicate isotope, activity, date, and users name.

4. Do not eat, drink, smoke, chew gum or touch exposed areas of skin while working with isotopes.

5. Use absorbent matting and trays to confine spills and reduce the potential for the spread of contamination.

6. Use automatic or remote pipetting devices. Never pipette radioactive materials by mouth.

7. Handle compounds which have potential for vapor or gas release in a hooded enclosure with adequate flow rate.

8. Traps may be necessary and should be incorporated for certain experimental procedures (e.g.: vacuum line traps). See Appendix XXII for more information.

9. Submit urine samples promptly for analysis if requested to do so by Radiation Safety.

10. Dispose of radioactive waste material promptly and properly. Follow the most current radioactive waste disposal guidelines provided by the Environmental Services Section. See Appendix VIII for radioactive waste packaging and disposal procedures.

11. Upon completing an experimental procedure, secure the radioactivity. Monitor yourself and work area. Decontaminate if necessary. Document survey.

12. In the event of a significant spill or other emergency, call the Radiation Safety Section at 785-3555 during normal working hours (8:30 am - 5:00 pm) After hours and on weekends and holidays contact Campus Police at 111.

13. In all cases of personal contamination notify Radiation Safety immediately. Radioisotope contamination directly on the skin can result in high doses to the skin and therefore requires prompt attention. When an accident or spill occurs, try to decontaminate yourself immediately and carefully with water and mild soap. Do not abrade the skin or spread the contamination. Call the Radiation Safety Section (785-3555) at the first available moment after initial decontamination efforts.

14. Secure all radioactive material from unauthorized use or removal from laboratory.

15. Handle and dispose of spin columns with care. Place used columns in a sealed container (capped tube or Ziploc® bag) prior to discarding into radioactive waste.

16. Allow sufficient time for frozen stock solutions to thaw before attempting to withdraw an aliquot. Consider using materials which can be stored in the refrigerator rather than the freezer.

17. Know the properties of the isotopes you will be handling. See the following pages for detailed information on ^{3}H, ^{14}C, ^{32}P, ^{35}S and ^{125}I.

Tritium (^{3}H) safety information and specific handling precautions

General:

Tritium is a very low energy beta emitter and even large amounts of this isotope pose no external dose hazard to persons exposed. The beta radiation cannot penetrate the outer protective dead layer of the skin of the body. The major concern for individuals working with this isotope is the possibility of an internal exposure. Such an exposure may occur if an individual contaminates bare skin, accidentally ingests the material, or breathes it in the form of a gas or vapor. The critical organ for a tritium uptake is the water of the whole body. Three to four hours after an intake of tritiated water, the radioactive material is uniformly distributed throughout the body fluids. A tritium intake may be easily detected by analyzing a urine sample.

Many tritium compounds readily migrate through gloves and skin. Data from accidents involving tritium indicate that 80% of the body exposure occurs through skin absorption. Tritium compounds should be handled with gloved hands, and in some cases, with double gloves. Change gloves often. Tritiated DNA precursors are considered more toxic than tritiated water. However, they are generally less volatile and do not normally present a significantly greater hazard.

Physical Data:

Maximum beta energy:	0.019 MeV, 100% emission.
Maximum range in air:	About 1/6 of an inch
Radiological Half-life:	12.28 years.

Internal Occupational Limits:

Annual Limits on Intake-
Inhalation: 80 mCi
Ingestion : 80 mCi

Precautions:

1. Follow General Safety Precautions for all isotopes (page 41).
2. Traps may be necessary to collect tritium if large gas or vapor releases are anticipated. This will reduce the release to the environment.
3. Monitor surfaces routinely and keep record of the results. Geiger counters (survey meters) are not sensitive to tritium radiation and therefore wipe tests and a liquid scintillation counter are necessary to determine levels of contamination.
4. Radiation badges are not issued to individuals using only tritium because the radiation emitted by tritium is not of sufficient energy to penetrate the badge.

5. Submit urine samples for analysis if requested to do so by the Radiation Safety Section. Yale's current Nuclear Regulatory Commission license requires an individual to submit a urine sample when working with 100 mCi or more of tritium at one time.

6. High activity tritium experiments may be performed in one of two laboratories (KBT 1138 and BCMM B-01) maintained by the Radiation Safety Section. Storage space is also available for high activity tritium stock solutions.

7. Due to the long half-life of tritium, tritiated waste must be segregated from short-lived waste. ^{3}H and ^{14}C waste may be combined, but must be kept separate from ^{32}P, ^{35}S, ^{125}I and other radioactive waste.

8. Tritium can leach through plastic and other materials. Stock vials should therefore be wipe tested routinely (i.e., quarterly) to help detect the escape of tritium from storage containers. ^{3}H vials which are going to be stored for extended periods of time should be double or triple bagged, to help control or limit the contamination of freezers.

Carbon-14 (^{14}C) safety information and specific handling precautions

General:

Carbon-14 is a low energy beta emitter and even large amounts of this isotope pose little external dose hazard to persons exposed. The beta radiation barely penetrates the outer protective dead layer of the skin of the body. The major concern for individuals working with this isotope is the possibility of an internal exposure. Such an exposure may occur if an individual contaminates bare skin, accidentally ingests the material, or breathes it in the form of a gas or vapor (usually radioactive CO_2). The critical organ for most ^{14}C labeled compounds is the fat of the whole body. The most hazardous chemical form of ^{14}C is labeled carbonates for which the bone is a critical organ. Ingested carbon is metabolized very quickly and much of the radionuclide is exhaled in the form of radioactive carbon dioxide. Depending on the chemical form used, urine analysis may be an effective sampling technique to determine if a ^{14}C uptake has occurred.

Some ^{14}C labeled compounds may migrate through gloves and skin. ^{14}C compounds should be handled with gloved hands, and in some cases, with double gloves. Change gloves often. One should be careful not to contaminate the skin as some ^{14}C beta particles penetrate the dead layer of the epidermis. Special caution should be taken when handling ^{14}C labeled halogenated acids. These compounds may be incorporated in the skin, causing very large skin doses and a pathway into the body.

Physical Data:

Maximum beta energy:	0.156 MeV, 100% emission
Maximum range in air:	about 8.6 inches
Radiological Half-life:	5730 years

Internal Occupational Limits:

Annual Limits on Intake-

Inhalation: 2 mCi

Ingestion: 2 mCi

Precautions:

1. Follow General Safety Precautions for all isotopes (page 41).

2. Traps may be necessary to collect radioactive carbon dioxide if large gas or vapor releases are anticipated. This is to reduce the release to the environment.

3. Monitor surfaces routinely and keep records of the results. Geiger counters are sensitive to the beta radiation from ^{14}C if the probe is used within a 1/2 inch of the surface and the proper probe is used. Radiation Safety recommends a pancake type probe and a meter with a linear scale. With such a probe very low amounts of ^{14}C may be detected on a surface**. Average efficiency for ^{14}C with a pancake probe is approximately 3%.** Do not cover the pancake probe with saran wrap® or parafilm®, etc. when using the probe to monitor for ^{14}C. This practice will decrease the efficiency of detection. Wipe tests should be taken and counted in a liquid scintillation counter for the most sensitivity when detecting removable surface contamination.

4. Radiation badges are not issued for individuals using ^{14}C as the radiation emitted by ^{14}C is not of sufficient energy to penetrate the badge.

Phosphorus-32 (^{32}P) safety information and specific handling precautions

General:

Phosphorus-32 is an energetic beta emitter which can penetrate up to 0.8 cm into living skin tissue. Therefore, this isotope poses an external (skin) dose hazard to persons as well as a potential internal hazard. An internal exposure may occur if an individual contaminates bare skin, accidentally ingests the material, splashes it into the eyes, or breathes it in the form of a gas or vapor. The bone is the critical organ for intake of ^{32}P transportable compounds. Although about 60% of ingested Phosphorus-32 is excreted within the first 24 hours, only 1% per day is excreted after the second or third day following ingestion. Urine samples should therefore be submitted immediately and regularly for analysis. Dose evaluations will require knowledge of the approximate date and time of exposure to the isotope.

The external hazard of ^{32}P can be reduced by applying the principles of time, distance and shielding. The dose rate at the top of an open vial containing 1 mCi of ^{32}P in 1 ml of liquid is roughly **26 rem/hour**! Since this dose rate will not be attenuated significantly by air, shielding materials should be placed between the source and personnel to absorb most of the radiation. Never work over an unshielded open container of ^{32}P. The best shield for a ^{32}P source is a material like lucite or plexiglass (about 1/2 inch thick), which will absorb the beta particles while generating little secondary radiation (Bremsstrahlung). For mCi amounts of ^{32}P, thin lead shielding (1/8 to 1/4 inch thickness) may be added to the exterior of the plexiglass shield to attenuate the higher intensity secondary radiation. However, thin sheets of lead should not be used alone to shield ^{32}P. In addition, the less time spent near a radiation source of ^{32}P, the lower the exposure.

A high local skin dose can be received if the radioactive material is touched and allowed to remain on the skin or gloves. An amount of 1 uCi of ^{32}P deposited in a 1 cm^2 area of bare skin would exceed the NRC annual skin exposure limit in less than eight hours. The face, eyes and hands can receive considerable exposure from an open container of ^{32}P, particularly if the radioactivity is in a concentrated form. The eye itself may receive a high local dose as well as providing a pathway into the body. The eyes should be protected from ^{32}P by wearing safety glasses. Safety goggles will prevent splashes from getting into the eyes and will also act as shielding for the eyes. The distance between you and a ^{32}P source can be easily increased by using remote handling devices such as tongs or forceps. This safe handling technique of using distance can substantially reduce exposure from ^{32}P.

Physical Data:

Maximum beta energy: 1.71 MeV, 100% emission.

Maximum range in air: 18 to 20 feet.

Radiological half-life: 14.29 days.

Internal Occupational Limits:

Annual Limits on Intake-

Inhalation: 0.9 mCi

Ingestion : 0.6 mCi

Precautions:

1. Follow General Safety Precautions for all isotopes (page 41).

2. Perform dry runs and practice routine operations to improve dexterity and speed before using ^{32}P.

3. Avoid skin exposure by using tools to indirectly handle unshielded sources and potentially contaminated vessels.

4. Monitor surfaces routinely and keep records of the results. Geiger counters with a pancake probe should be used for ^{32}P radiation. **Average efficiency for detecting ^{32}P with a pancake probe is 30%.** Always survey hands, forearms, lab coat, clothes and bottom of shoes after using ^{32}P. Use wipe tests and a Liquid Scintillation Counter to determine levels of removable ^{32}P contamination.

5. Do not work over open containers of ^{32}P without shielding. Work with plexiglass shields (1/4 to 1/2 inch thickness). Shield all stock vials of ^{32}P. Do not use thin sheets of lead to shield ^{32}P.

6. Radiation badges are issued to individuals working with significant activities of ^{32}P. Individuals working with 10 mCi or greater will be issued an extremity dosimeter. Wear, store and return radiation badges as instructed by Radiation Safety.

Sulfur-35 (^{35}S) safety information and specific handling precautions

General:

Sulfur-35 is a low energy beta emitter and even large amounts of this isotope pose no external dose hazard to persons exposed. The beta radiation barely penetrates the outer protective dead layer of the skin of the body. The major concern for individuals working with this isotope is the possibility of an internal exposure. Such an exposure may occur if an individual contaminates bare skin, accidentally ingests the material, or breathes it in the form of a gas or vapor. The critical organ for most ^{35}S labeled compounds is the whole body. Urine analysis is an effective sampling technique to determine if a ^{35}S uptake has occurred.

Some ^{35}S labeled compounds may migrate through gloves and skin. ^{35}S compounds should be handled with gloved hands, and in some cases, with double gloves. Change gloves often. One should be careful not to contaminate the skin as some ^{35}S beta particles penetrate the dead layer of the epidermis. Some ^{35}S compounds may be incorporated in the skin causing very large skin doses and a pathway into the body. Certain forms of ^{35}S (methionine, cysteine and Translabel®) are volatile. Use a hooded enclosure, when possible, while handling volatile forms of ^{35}S. Activated charcoal is effective in helping to trap volatile species.

Physical Data:

Maximum beta energy:	0.167 MeV, 100% emission
Maximum range in air:	about 9.6 inches
Radiological half-life:	87.4 days

Internal Occupational Limits:

Annual Limit on Intake-

Inhalation: 20 mCi

Ingestion : 8 mCi.

Precautions:

1. Follow General Safety Precautions for all isotopes (page 41).

2. Traps may be necessary if large gas or vapor releases are anticipated. This is to reduce the release to the environment. It may be necessary to incorporate activated charcoal into experiments involving volatile forms of ^{35}S.

3. Monitor surfaces routinely and keep record of the results. Geiger counters are sensitive to the beta radiation from ^{35}S if the probe is used within a 1/2 inch of the surface and the proper probe is used. The Radiation Safety Section recommends a pancake type probe and a meter with a linear scale. With such a probe very low amounts of ^{35}S may be detected on the surface. **Average efficiency for ^{35}S with a pancake probe is approximately 8%.** Do not cover the pancake probe with saran wrap® or parafilm®, etc. when using the probe to monitor for ^{35}S. This practice will decrease the efficiency of detection. Wipe tests should be taken and counted in a Liquid Scintillation Counter for the most sensitivity when detecting removable surface contamination.

4. Radiation badges are not issued for individuals using ^{35}S as the radiation emitted by ^{35}S is not of sufficient energy to penetrate the badge.

5. Do not repeatedly thaw and freeze ^{35}S stock vials. After the initial thaw, aliquot the ^{35}S into single use tubes, for subsequent frozen storage. Proper tubes should be used for storage of these single use aliquots of volatile ^{35}S material. Screw top tubes with rubber seals are recommended.

Iodine-125 (^{125}I) safety information and specific handling precautions

General:

^{125}I is considered toxic because of its affinity for the thyroid gland. Accordingly, allowable air and water concentrations are extremely low, making it extremely important that the release of radioiodine in the laboratory be controlled. Unbound radioiodine is extremely volatile and must be handled appropriately. Radioiodine is biologically active, and up to 30% of any activity ingested may concentrate in the thyroid gland. The maximum permissible levels of contamination in non-ventilated areas are well below the detection limit for a typical Geiger counter. Therefore, a thin crystal sodium iodide detector is recommended. Average efficiency for detecting ^{125}I with a sodium iodide probe is approximately 30%. ^{125}I decays with a half-life of 60 days. It emits soft gamma radiation and x-rays with a maximum energy of about 35 KeV; also emitted are conversion and auger electrons with a maximum energy of about 35 KeV. Radioiodine metabolized by the thyroid gland has an effective half-life in the thyroid gland of about six weeks.

Physical Data:

Maximum gamma radiation energy:	35 KeV
Maximum range in air:	N/A
Radiological half-life:	60 days

Internal Occupational Limits:

Annual Limits on Intake:

Inhalation: .06 mCi

Ingestion : .04 mCi

Precautions:

1. Follow General Safety Precautions for all isotopes (page 41).
2. Use forceps fitted with rubber sleeves to ensure a secure grip on containers.
3. Radiation badges should be worn by all personnel involved in performing iodinations.
4. Radiation Safety approved hoods must always be used when performing iodinations.

5. Never remove the rubber vial septum on containers of volatile iodine! Remove all $Na^{125}I$ aliquots with Hamilton® or disposable hypodermic syringes inserted through the vial's rubber septum. The stock vial containing $Na^{125}I$ should be purged with a charcoal trap before beginning the experiment. The Radiation Safety Section can supply you with charcoal traps.

6. If the iodination procedure requires a vacuum withdrawal of supernate or other substance containing iodine, an iodine trap should be placed between the collection flask and the vacuum source in order to protect the house vacuum line from contamination.

7. Store $Na^{125}I$ solutions at room temperature in an approved hood, do not freeze and avoid heating $Na^{125}I$ solutions as this will result in subsequent volatilization.

8. Maintain a pH greater than 7 in $Na^{125}I$ solutions in order to reduce volatilization.

9. Have reducing agents available when using $Na^{125}I$. Sodium Metabisulfite is an effective antioxidant and decontaminant. It can be made by combining the following ingredients:

   30 ml NaOH solution (@6M)
   4 grams $Na_2S_2O_5$
   0.5 grams KI
   450 ml H_2O

10. In the event of a spill involving volatile $Na^{125}I$ hold your breath and vacate the iodination area closing the doors behind you. Do not permit anyone to enter the spill area and contact the Radiation Safety Section immediately.

11. Thyroid counts should be obtained by all individuals prior to working with radioactive iodine. Thyroid counts are also required for those individuals performing iodinations 6 to 72 hours post each iodination. Quarterly thyroid counts may be required for individuals who work with iodine but do not actually perform iodinations. More information pertaining to thyroid counts may be obtained by calling 737-2139 or 785-4250. Thyroid counts are performed each weekday morning, Monday through Friday, from 9:00 AM to 10:00 AM in BCMM B-01. Appointments are not necessary.

There are two supervised labs available for the performance of iodinations. They are located at 1138 KBT and B-01 BCMM. These laboratories are equipped with protective matting, charcoal traps, fume hoods, air sampling apparatus and other laboratory equipment. All iodinations should be performed in one of these laboratories unless an alternative fume hood has been approved for iodinations by the Radiation Safety Section. Use of these laboratories is available by appointment by calling 737-2139 or 785-4250. Personnel from the Radiation Safety Section will supervise all first iodinations by individual researchers at Yale University to offer safe handling tips.

Stock vials containing mCi amounts of ^{125}I should be shielded. A thickness of 2 millimeters of lead is sufficient to shield standard, ^{125}I stock vials.

When handling potentially volatile ^{125}I, perform the reaction in the original shipping vial, working through the septum with a syringe and hypodermic needle. All stock vials containing volatile ^{125}I compounds should be purged prior to use. Purging the airspace of the stock vial through a trap containing activated charcoal will prevent an initial release of built-up volatilized activity. This will assist in significantly reducing environmental releases, contamination of facilities and possible internal personnel exposures. Purging is accomplished by first inserting the hypodermics of both a charcoal trap and an air filled syringe through the septum of the closed stock vial (depicted in Diagram 1). Be certain that the tips of the hypodermics reside in the airspace of the stock vial and are not touching the liquid. Slowly and gently force the air from the syringe into the stock vial, causing an exchange of air and forcing the volatilized activity from the stock vial into the charcoal trap. Remove the syringe and then the charcoal trap. Discard the used syringe and the charcoal trap into the ^{125}I sharps waste. Do not recap hypodermic needles. Charcoal traps are available free of charge from the Radiation Safety Section. Please call 785-4250 for more information or to obtain a charcoal trap.

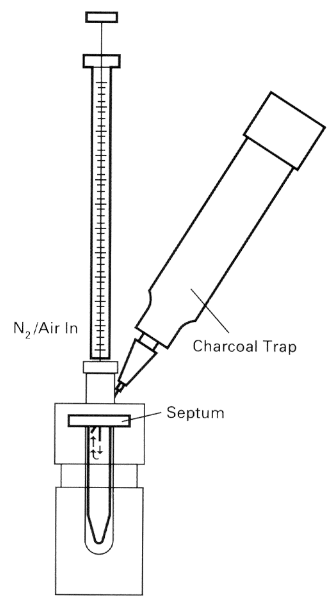


Diagram 1

APPENDIX - V GUIDE TO LABORATORY SURVEYS

Introduction

Routine laboratory surveys are an important part of the overall radiation safety program in a laboratory. Surveys provide a direct measure of the presence of radioactive material inadvertently spilled on a person, surface or piece of equipment, and are an indication of the radiation hazard during an experiment. It is vital that individuals working with radioactive materials are aware of accepted procedures for performing such surveys. The information which follows is a suggested guide for performing surveys of laboratory areas. Questions about the mechanics of performing surveys or the interpretation of this guide may be referred to the Radiation Safety Section.

What Is Contamination?

There are two types of contamination - "REMOVABLE" and "FIXED". Removable contamination is that which may be wiped off a surface or object, similar to dust on a piece of furniture. The presence of removable contamination is determined by wipe tests, and in some situations by the use of a survey meter. If contamination is present in large enough quantities and is removable, it may also be detected by a survey meter when a wipe test of the surface is placed near the probe. Fixed contamination is that which has become bound by chemical or other means to the surface upon which it was deposited. This form of contamination can only be detected by a survey meter. Because it is fixed to the surface, a wipe test will indicate no activity. A meter survey may indicate that large quantities are indeed present on the surface.

What Is a Survey?

A survey is an evaluation of work areas, instruments and apparatus, floors, sinks, faucet handles, drawer fronts, doorknobs, telephones, light switches, refrigerators, etc. for the presence of radioactive contamination. The following methods can be used to perform a survey:

1. wipe test
2. survey meter scan

Survey results should be documented. These records should also be kept in such a manner that all information is readily obtainable by laboratory staff, for inspection by the Radiation Safety Section, and Federal and State Regulatory Agencies.

How is a Wipe Test Survey Performed?

A filter paper, such as Whatman 41 or its equivalent, should be used. An area of ~ 100 cm^2, or an object, is simply wiped with the filter paper. The filter paper is then placed in a liquid scintillation vial with a sufficient quantity of scintillation cocktail (Optifluor, Ultima Gold or an approved equivalent) and counted in a liquid scintillation counter (LSC). It is necessary to establish a background level. To do this, follow the above procedure with an unused filter paper. Be certain that the LSC is equipped to count all the isotopes that may be used in the laboratory (see next section). The amount of contamination is the difference between the count rate of the actual wipe test and the background count rate. An area should be cleaned if this difference (wipe test CPM – background CPM) is greater than 100 counts per minute. Save the LSC data sheet. When numerous wipes are being taken, such as when a complete lab survey is being performed, locations of wipes should be recorded on a lab diagram. If one or more wipes reveals contamination, the location of the contamination can then be determined.

Liquid Scintillation Counting

Liquid scintillation counting is a method of assaying a radioactive sample by surrounding or dissolving that sample in a solution that fluoresces (emits light) when the solution absorbs the energy of the radiation. The light flashes are detected by the scintillation counter and are converted to electronic pulses that are proportional to the energy of the radiation. The pulses are then analyzed and the sample assayed.

Liquid scintillation counting is an excellent way to quantify beta activity. It can also be used to distinguish between (and quantify) beta emitters if the beta energies are significantly different. Liquid scintillation counters are normally manufactured so that differing energy "windows" or "channels" can be pre programmed into the counter. These channels are set based on energy levels of the nuclides to be counted. Examples of nuclides and their maximum beta energy levels typically used and counted here at Yale include:

Nuclide	Max Beta Energy
^{3}H	18.6 kev
^{14}C	156.0 kev
^{35}S	167.0 kev
^{33}P	256.0 kev
^{32}P	1710.0 kev

Typical liquid scintillation counters generally have three channels in which detected counts are listed. The channels correspond with energy levels of the nuclides being counted. When using a liquid scintillation counter, be sure to check the program you are counting your samples on, to verify your samples energy is within the counted spectrum. Many lab scintillation counters are set so that ^{3}H counts appear in the first channel, ^{14}C and ^{35}S counts show up in the second or middle channel, and ^{32}P appears in the third channel. Samples can also be counted "wide open" so that a fuller range of beta energies will be included. This will, however, result in an elevated background count rate.

What is a Survey Meter?

A survey meter is a portable handheld, electronic instrument consisting of three elements. It is used to detect ionizing radiation. The three elements are:

1. Probe: converts the incident ionizing radiation to an electrical signal which is sent to the electronics package.
2. Electronics Package: converts the electrical signal to a visual indication on the meter scale of the intensity of the ionizing radiation field.
3. Speaker (Optional): provides an audible indication in addition to the visual.

It is recommended that a "pancake" type Geiger Mueller (GM) probe be used for isotopes which emit beta radiation and an energy compensated GM probe be used for gamma emitting isotopes, except for ^{125}I. A low energy gamma scintillation detector (solid crystal) should be used for ^{125}I. It should be noted that **^{3}H cannot be detected at all with a standard lab survey meter**. Wipe test surveys must be performed to monitor for ^{3}H contamination. Please contact the Radiation Safety Section for information on what type of instrument is best for specific applications, and for vendor information.

MODEL 44-38
Energy Compensated
Thin Wall G-M Detector

MODEL 44-9
Pancake G-M Detector

MODEL 44-3
Low Energy Gamma Scintillator

Meter Function Tests

Each time the meter is turned on, the batteries should be checked. There is a battery check position on the range switch of most quality units. Changing weak or dead batteries will greatly increase the life of your instrument as batteries can leak a corrosive liquid, which may destroy the unit or result in costly repairs.

The cable connecting the probe to the electronics package is another element that should be checked. With prolonged use this cable may become defective, giving either no reading or false high readings sporadically, even in the absence of a radiation field. If you suspect there is a problem with the cable, switch cables with another meter that is working properly. If the meter response is normal, then you have a “bad” cable. If you need information on meter supplies, please contact the Radiation Safety Section at 785-3550.

One should verify than an instrument does indeed respond to a radiation field. This may be performed by using a "check source", or alternatively, a known source of radiation in your laboratory. A check source contains a very small quantity of radioactive material, commonly in the form of a disk. This disk may be securely glued or epoxied to the side of a meter. A measurement should be taken at a constant distance. This reading should be recorded as an operational check.

How to Perform a Meter Survey

Once batteries have been checked and meter is confirmed to be operational, the range switch on the meter should be rotated all the way to the lowest number. This is the most sensitive scale. With the appropriate probe, a meter survey is conducted by slowly passing the probe over the area or object to be surveyed. Be certain that the pass is at a constant velocity (1 probe width per sec is recommended) and sufficient time is allowed for the meter to respond. The distance from the contaminated object or area should also be constant. A distance of 1cm is suggested. Care should be taken not to contaminate the probe itself!

Begin any survey by checking yourself first. Each finger should be checked with special attention paid to thumbs. Wrist and forearm areas should be surveyed as well as lab coat sleeves, fronts and pockets. Personal surveys should also include monitoring the bottoms of shoes. Shoe soles are a excellent indicator of the presence or absence of floor contamination.

All readings should be recorded. When recording measurements, counts per minute (cpm) or milliroentgens per hour (mR/hr) should be used. The correct unit is determined by the type of probe being used. When a pancake or scintillation probe is used, cpm is the correct unit. When the energy compensated probe is used, mR/hr is the correct unit. Questions related to the correct use of units should be directed to the Radiation Safety Section.

Please be certain that all readings are recorded as "net". To do this, determine the normal background reading by observing a meter reading in an area where radioactive materials are not used or stored. Subtract this reading from all other measurements taken, prior to recording them.

It is normal to observe fluctuations on the meter scale, particularly near areas of low contamination. In this event use an average of the meter fluctuation. General background readings found in Yale buildings are usually from 30 – 150 cpm with a pancake probe and 200 – 500 cpm with a scintillation probe.

How Often Are Surveys to be Performed?

Individuals should survey themselves and their work areas on an "as used" or "daily basis". Radiation Safety recommends frequent surveys of hands and other skin areas to identify and rectify contamination, thus preventing significant doses and internal exposures. An operating survey meter should be within arms reach whenever working with radioactivity.

The Radiation Safety Section suggests that complete surveys of work areas (wipe tests and meter surveys) be performed at a frequency which is commensurate with your isotope work and probability of contamination**. Such surveys should be fully documented and should be performed at least monthly**. The frequency of surveys may need to be increased depending on the radioisotope use in your area. Situations or circumstances may dictate an increased frequency. Call the Radiation Safety Section for advice.

How to document Surveys Properly

It is suggested that all documentation of lab surveys contain the following information:

1. Room number and floor plan map;

2. Location number, indicating on the map where the wipe test or meter reading was taken;

3. Wipe test results (even if background), such as liquid scintillation counter printout;

4. Survey meter results (even if background);

5. Name of person performing the survey;

6. Date of survey;

7. If applicable, list the monitoring results following decontamination to include:
   a. wipe test
   b. survey meter reading

Personal and post experimental surveys may be documented using the check off sheet on the following page.

Personal monitoring checklist - sample

The following areas should be monitored after each experiment which involves radioisotopes. Please be sure that the proper survey instrument is used.

Personal Survey					Work Area Survey				
Name	**Date**	**Hands**	**Body**	**Shoes**	**Work Bench**	**Floor**	**Equip**	**Regular Trash**	**Describe Any Contamination Found**

Please indicate any contamination found and results after cleaning. Also, skin contamination and spills should be reported to the Radiation Safety Section immediately at 785-3555.

APPENDIX - VI RECOMMENDED PROCEDURES FOR HANDLING PACKAGES CONTAINING RADIOACTIVE MATERIAL

Receiving the Package

1. Protective clothing (gloves, lab coat, safety glasses) should be donned before handling radioactive materials.

2. All radioisotope shipments should be opened immediately and surveyed (as directed below) by personnel in the receiving laboratory, and then stored in a locked, labeled radioisotope storage area.

Note: Only authorized, trained users of radioactive materials may accept and sign for radioactive packages.

Opening the Package

1. Place package in vented hood (if available) or other designated radioactive work area.

2. Take a measurement on the external surface of the package with a survey meter. Compare this reading to similar packages previously received, to insure the vendor has shipped the correct quantity of material.

3. If the package contains gamma or high energy beta emitters, check dose rate on outside of package with an energy compensating probe or ionization chamber.

4. Open outer package and remove packing slip. Open inner package and verify that the contents agree in name and quantity with isotope and quantity ordered.

5. Check for possible breakage of seals or containers, loss of liquid or change in color of absorbent material.

6. Wipe test innermost container and count for activity.

7. Upon verification that package is contamination free, store material appropriately.

8. If contamination, leakage or variations in isotope, or quantity ordered are observed, notify Radiation Safety (785-3550).

Discarding Packaging Materials

1. Deface or destroy all radioactive labels on the empty container. Outer containers which have had labels defaced and are free of contamination may be disposed of as normal trash, once the cardboard container has been flattened.

2. All boxes must be left visibly empty for proper disposal. No containers may be discarded as closed boxes in the regular trash. Lids should be left ajar and dry ice should be removed prior to disposal. Cardboard containers must be torn or otherwise disassembled so as to make them useless.

3. Styrofoam boxes which are free of contamination may be recycled according to manufacturer's directions.

4. The liner, shield and isotope container may have surface contamination; they should be discarded as radioactive waste.

Recording/Reporting Results

1. NRC regulations dictate that each PI/laboratory must be able to account for the whereabouts of all radioactive material received in the laboratory. Therefore, complete the top portion of a "Radioactive Material Use Log" (see sample on next page) for each vial received. Post log in location convenient for completion as material is used.

2. Attach wipe test results to bottom of log sheet.

3. If contamination, leakage, or variations in isotope or quantity ordered are observed, notify Radiation Safety immediately (785-3550).

Radioactive Material
Use Log

Stock Vial I.D.

____

Isotope: __________________ Chemical form: _____________

Activity: _________________ Reference Date:_____________

Date Used	Quantity Used (uCi)	Amount Remaining (uCi)	User's initials

Survey Date:___________________ Surveyed By:__________________

Affix Wipe Tests Here:

APPENDIX - VII PROCEDURES FOR TRANSPORTING AND SHIPPING RADIOACTIVE MATERIAL

There are four types of transfers of radioactive materials and each transfer mechanism has specific requirements. These requirements are regulated by federal, state and international law and severe penalties may be levied on individuals not in strict compliance with these laws. It is the **RESPONSIBILITY OF THE PRINCIPAL INVESTIGATOR** to comply with the guidelines provided in this appendix. The four types of radioactive materials transfers originating at Yale are:

I. Transfers within the workplace.

II. Transfers within the University.

III. Transfers between Yale and other institutions within the United States.

IV. International transfers.

Each of these transfer mechanisms is discussed below.

I. Transfers within the workplace:

This type of transfer involves the relocation of radioactive material from one authorized lab or area to another that is connected by corridors, overpasses, or tunnels, i.e., the material is **not** taken outside. Radiation Safety must be contacted (785-3552), in advance, and informed of radioactive transfers within the workplace, to confirm recipient Principal Investigator is licensed to possess isotope and quantity being transferred.

II. Transfers within the University:

Transfers within the University are defined as any amount of radioactivity being transported from one University facility to another using New Haven city streets (as opposed to transport between University buildings interconnected with overpasses or tunnels). To conduct such a transfer, please refer to the items below:

A. Notify the Radiation Safety Section (RSS) of your need to transfer radioactivity within the University (call 785-3552 or 737-4128). Advance notice must be given to Radiation Safety to allow for the required proper packaging of your material and for transportation planning.

B. Radiation Safety will confirm the Principal Investigator receiving your radioactive material is authorized for the type and quantity being transferred.

C. Your radioactive material must be packaged under supervision by the RSS. Certified shipping containers will be provided by Radiation Safety for this purpose. This is to ensure compliance with the United States Department of Transportation, the United States Nuclear Regulatory Commission, and the State of Connecticut Department of Environmental Protection regulations concerning such transfers.

D. The activity, in microcuries or millicuries, of radioactive material to be shipped must be accurately calculated when supplied to Radiation Safety.

E. Radiation Safety will require signature(s) on certain provided document(s) recording the date, name of individual transporting the radioactive materials, the Principal Investigator sending the material, the receiving Principal Investigator, laboratory locations, and radioisotope name and quantity.

F. Once transfer is complete, update your radioactive materials inventory to reflect change.

Please note: Only certain Yale vehicles are authorized for use in the transfer of radioactive material between University locations. The use of public transportation (buses, taxies and the Yale Shuttle) and personal vehicles for transporting radioactive material is strictly prohibited by governmental and University regulations.

III. <u>Transfers between Yale and Other Institutions within the U.S.A</u>

Notify the Radiation Safety Section (RSS) (785-3552 or 737-4128) of all intended transfers of radioactive material to other institutions well in advance of the anticipated date of shipment. RSS will provide the proper containers, packaging components, labels, and documents required to ship your radioactive material in compliance with government and university regulations.

A. Provide the following:

1. Your name, campus address, and phone number.
2. The radionuclide name.
3. The amount of activity (uCi or mCi) you plan to ship.
4. Chemical and physical form of the material.
5. Volume (in ml) or mass (in grams).
6. If the shipment requires dry ice or ice packs.

B. Contact the Radiation Safety Office at the institution you intend to ship radioactive material to and:

1. Inform them of the name of the person you plan to send the material to and the isotopes and quantities to be sent.

2. Ask them to FAX, to your lab or office, an acceptance statement confirming their institution will receive and accept your material. This statement must include:

a.) the radionuclide name.
b.) the activity amount (mCi or uCi), and
c.) the chemical form of the material they will accept upon arrival, plus
d.) the exact mailing address of the location where the radioactive package will be received.

3. Ask them to provide you with a copy of their NRC or agreement state license (only if Yale RSS requests this).

IV. International Shipments

A. Procedures for international shipments of radioactive material will be provided by the Radiation Safety Section as needed. Such shipments generally require special consideration. Also, due to the transportation restrictions of some foreign countries, it may not be feasible to transfer radioactive material to all countries. Please contact Yale Radiation Safety prior to the completion of any plans to perform experiments that will result in the production of radioactive material you intend to ship outside the USA. RSS can make a prior determination if any transportation problems might be encountered that would prevent the transfer of your material.

APPENDIX - VIII RADIOACTIVE WASTE PACKAGING AND DISPOSAL PROCEDURES

Radioactive waste must be disposed of in approved containers using approved techniques. It is a violation of federal and state regulations to dispose of radioactive waste in the normal trash or by any other non-approved method. The following procedures must be adhered to, in order to assure the safe and legal disposal of all forms of radioactive waste. Situations occurring where radioactive waste is disposed of improperly, should be brought to the attention of the Radiation Safety Section at 785-3555 immediately.

Waste minimization techniques should be considered when designing protocols. Less hazardous radioisotope and chemicals should be used when possible.

The Environmental Services Section of the Office of Environmental Health and Safety manages the radioactive waste disposal program. Special containers are provided by Environmental Services for the collection of each of the different forms of radioactive waste. Six primary forms of radioactive waste are normally generated in the research labs at Yale. The appropriate procedures for disposing of each of these forms is discussed in detail starting on the following page.

In general, the following separation by half-life protocol should be adhered to for each type of waste, except as noted.

Class I – Isotopes with half-life $\leq$ 30 days.
Class II – Isotopes with half-life > 30 and $\leq$ 120 days
Class III – Isotopes with half-life > 120 days
Class IV – ^{3}H and ^{14}C

All radioactive waste containers shall be labeled using a numbered radioactive materials tag (provided by Environmental Services) prior to pickup by Environmental Services. The information to be supplied on this tag includes:

- Radioisotope content
- Activity per radioisotope in millicuries
- Solute chemical form(s) of the radioisotopic constituents (for non-dilute stock solution only)
- Solvent chemical form(s) of the solution [liquid waste only]with approximate (%) by volume
- pH of the solution [liquid waste stream only]
- Principal Investigator's name
- Name of the person labeling the waste
- Date that the waste was labeled

To place a request for radioactive waste pick-up, call the Office of Environmental Health and Safety at 785-3551. Laboratory personnel placing this call will need to provide the information listed above, along with the unique tag number. Radioactive waste pick-ups are normally performed on Mondays, Wednesdays and Fridays. Specific questions about radioactive waste disposal will be forwarded to Environmental Services personnel.
All radioactive waste receptacles must be kept in the laboratory, not in the hall or other

unsecured area. The presence of the receptacle within the laboratory should not constitute a health hazard. If significant dose rates are associated with the container, special arrangements should be made through the Radiation Safety Section for recommendations concerning proper shielding or different methods for handling the waste.

Dry Waste

Dry radioactive waste (gloves, absorbent material, etc..) shall be contained in plastic lined cardboard dry waste boxes provided by Environmental Services. There are three sizes of dry waste boxes available for use:

small (1/4) box	˜ 9.5" (width) x 9.5" (depth) x 25" (height)
medium (1/2) box	˜ 9.5" (width) x 19" (depth) x 25" (height)
large (full) box	˜ 19" (width) x 19" (depth) x 25" (height)

These receptacles are identified with the magenta and yellow radiation symbol and the words "caution - radioactive material".

Radioactive waste placed in dry waste boxes shall **NOT** include any liquids, animal tissue, animal excreta, blood products, lead [Pb] (see the section on lead shipping containers) or loose sharp objects, i.e., any object likely to cause a laceration or puncture wound. Completely empty stock vials may be placed in a dry waste box. Items not classified as sharps, but having the potential to rip a bag (such as plastic pipettes), may be placed into sharps containers or small cardboard boxes, prior to placing in dry waste box.

Segregation of dry radioactive waste by half-life class is required. To assist with the segregation process, a small yellow and magenta isotope sticker will be placed outside of the box on the plastic liner to identify which isotope belongs in each box. Advice on handling waste from dual label protocols will be provided during the approval of the experimental protocol.

Material must not be put into radioactive waste containers if there is the possibility of a chemical reaction during storage or shipment that might cause a fire, explosion, or the release of radioactive gases.

Special care must be exercised in storing radioactive waste containing volatile isotopes (e.g.; iodine isotopes and some forms of ^{35}S). It is suggested that these wastes be double bagged and properly sealed. Activated charcoal can be added to waste to assist with the control of this potential volatility problem.

As any radioactive waste receptacle is being filled, records should be kept of the quantities being placed in the container. When the dry radioactive waste box is 3/4 full, fill out the radioactive materials (RAM) tag and attach it to the outside of the plastic bag. Assure that the RAM tag is not obscured from view by the box flaps or the plastic liner. Any items with a biological component must be deactivated prior to placement in the dry waste box (see the section on sharps disposal for deactivation alternatives).

Note: Environmental Services will normally only remove the bag, unless the box needs replacement.

Sharps Waste

All sharps (needles, syringes, broken glass, razor blades, scalpel blades, microtome blades, microscope slides/covers, pipette tips, Pasteur pipettes, or any object likely to cause a laceration or puncture wound) contaminated with radioactive material shall be deposited into a plastic yellow sharps container provided by Environmental Services.

Segregation of sharps radioactive waste by half-life class is required. Two sizes of sharps containers are available, 1-gallon and 3-gallon. Filled yellow sharps containers shall be discarded into a dry radioactive waste box appropriate with both size and radioisotope. Sharps containers do not require separate RAM tags for disposal, if placed inside a dry waste box. The isotopic content, activity and chemical form must be accounted for on the RAM tag for the dry waste box. The placement of a 3-gallon sharps container into a small (1/4) size dry waste box should be avoided.

Sharps containers housing biological and radioactive sharps waste shall be chemically deactivated whenever possible, in lieu of autoclaving. For chemical decontamination (of other than radioiodines), pour a 1:10 dilution of chlorox and water into the opening of the sharps container until the container is full. Close the lid over the opening of the sharps container, and let the chlorox remain overnight. Invert the container in a radioactive materials sink to drain off the solution. Account for any activity which may be drain disposed. Use iodine solutions such as Wescodyne, for deactivation of radioiodine wastes. When autoclaving is unavoidable, please consider the following: Explosive chemicals must never be autoclaved. When autoclaving, close the lid over the opening of the sharps container. To facilitate the displacement of cold air in the sharps container, place the sharps container on its side in the autoclave. Autoclave the sharps container at 250° F at 15 psi for 60 minutes. Once autoclave has cooled, survey for radioactive contamination.

Liquid Waste

One and five gallon plastic jugs are provided by Environmental Services for the collection of radioactive liquid waste. The liquid waste shall be segregated by half-life class. The jugs shall contain liquid material only. Call Environmental Services at 785-3551, if special consideration must be given to another type of container due to chemical incompatibility with the plastic jugs. It is strongly suggested that all liquid waste jugs be stored in secondary containers to contain spills or leaks. Secondary containers are available from Environmental Services.

The radioactive material [RAM] tag shall be affixed to the jug. The RAM tag shall contain the following additional information:

- Solute chemical form (for non-dilute stock solutions ONLY),
- Solvent chemical form (chemical in which the radiochemical was dissolved, e.g., water, TRIS buffer, dilute hydrochloric acid, etc.), with approximate percentages by volume. No abbreviations or chemical symbols allowed.
- pH of the solution. Protocols should include methods for the neutralization of chemicals. The pH of the solution shall be between 5.5 and 9.5 at 20° C. If you have any questions as to how to neutralize out-of-range (pH <5.5 or >9.5) solutions please call Environmental Services at 785-3551 for instructions.

Liquid waste must be deactivated if contaminated with biologically hazardous material.

Soluble low-level liquid waste (sub uCi amounts), disposed down the drain, must conform on a University wide basis, to numerous regulations. The CT Department of Environmental Protection, US Nuclear Regulatory Commission, US Environmental Protection Agency, and the City of New Haven Water Pollution Control Authority all regulate sewer disposals. When radioactive material must be released to the sanitary sewer by sink, all of the requirements of the above named agencies must be met and documented. This means the material/chemical form must be readily soluble in room temperature water and that the sewer disposals must be limited as much as possible. Sewer disposal should generally be limited to low activity/high volume liquids such as that generated from washing non-disposable lab equipment that has come in contact with RAM. Third washes that contain very low levels of activity may also be sewer disposed. Whenever feasible, other liquids containing RAM should be collected into liquids waste jugs provided by the ESS.

The sewer disposal activity limit has been decreased to 520 microcuries per quarter, for an AVERAGE of 40 microcuries per week. [NOTE: If necessary, PIs may apply for approval for an increase beyond this limit if conditions/laboratory protocols require such consideration.] Run water when discarding liquid radioactive material down the sink. Only sinks designated and labeled for this purpose should be used. Information on the isotopes and amounts disposed down the drain must be accurately recorded and reported to Radiation Safety on a quarterly basis. A disposal log should be kept near the sink where such disposals occur. This log should include the date, isotope and activity disposed. An example form can be found on the following page.

RADIOACTIVE MATERIAL
SINK DISPOSAL LOG

DATE	ISOTOPE	uCi ACTIVITY	INITIALS

Animal Carcasses

All animal carcasses shall first be placed in a plastic bag and then in a kraft bag [brown paper bag provided by Yale Animal Resource Center]. Animal Carcass, animal tissue/parts, and animal excreta/bedding may be placed together in the same bag for the same animal. Animal carcass waste bags must **NOT** contain:

Needles	Syringes
Knives	Razor Blades
Glass	Glassware
Sharps	*Polyvinyl chloride plastics (surgical implants)
Scalpels	Pipettes
Ceramics	*Metals (surgical implants)

*may be allowable – contact Environmental Services Section

Once the animal carcass, etc. has been double bagged [plastic & kraft bags], it must be frozen for at least twenty-four hours prior to pickup by Environmental Services. The RAM tag must be placed on the outermost bag.

Liquid Scintillation Vials

All liquid scintillation vials (LSV's) are to be placed in containers provided by Environmental Services. No other containers are acceptable. Different sized drums are available (13, 30 and 55 gallons).

Only Yale University approved, environmentally safe, liquid scintillation fluors are allowed to be used. The following is a list of currently approved fluors:

BetaMax	CytoScint ES	Safescint	Ultima Flo
Ecolite	Ecolume	ReadySafe	Universol ES
Ecoscint	Optifluor	Ultima Gold	

Permission to use fluors other than those listed above must be obtained from Radiation Safety (737-2140). Call Radiation Safety, if you have any questions about University-approved fluors.

Segregate vials that contain ^{3}H and ^{14}C into the same container. All vials containing other radioisotopes shall be separated by half-life class. The RAM tag shall be affixed to the top of the container. Do not affix the RAM tag to the side of the container. **All** LSV containers must have the fluor type clearly marked on the RAM tag. Containers with unapproved fluors may not be accepted by Environmental Services. It is important with LSV waste that activity be accurately calculated and recorded to ensure proper disposal.

Stock Vials

Stock vials containing radioactive solutions shall be disposed of by following these steps:

1. Place the stock vial(s) in an appropriately sized box.
2. Place the box inside a plastic bag and tape the bag shut.
3. Place a RAM tag on the outside of the plastic bag.

Empty/dry stock vials may be placed in a dry waste box.
Stock vials must not be disposed with liquid scintillation vials.

Lead [Pb] Shipping Containers

Many stock vials are shipped from vendors within lead [Pb] shielded containers. Please observe the following guidelines to dispose of these shipping containers:

Note: Gloves are recommended when handling lead.

If the stock vial is completely empty, the lead container must be separated from its plastic covering, placed inside a plastic bag and taped closed. **DO NOT** put lead shipping containers into any normal radioactive waste stream, e.g., dry waste. Place the lead into a plastic bag, and place a RAM sticker on it. Do not use a waste tag unless lead is known to be contaminated. Contact Environmental Services for pick up.

If the stock vial contains radioactive material, keep the lead-lined shipping container intact, and prepare the stock vial for pickup as outlined in the above section.

Additional Radioactive Waste Disposal Information

The chemical solution of the liquid radioactive waste and liquid scintillation vial wastes is extremely important in determining compliance issues and the proper method of disposal. Researchers are required to provide the chemical name(s) of each solvent on the RAM tag. Non-hazardous trace chemicals may be excluded. Any quantity of hazardous chemicals such as sodium azide, mercury and various cyanide salts must be listed.

Researchers have the responsibility to assure that **all** biohazardous radioactive waste is rendered biologically inert before contacting Environmental Services for pickup.

It is very important that liquid waste and lead [Pb] not be placed in the dry waste containers.

Please ensure that **ALL** objects capable of causing puncture or laceration wounds be placed in a sharps container.

Call for radioactive waste pickups before waste containers are full. Most radioactive waste will be picked up within two business days.

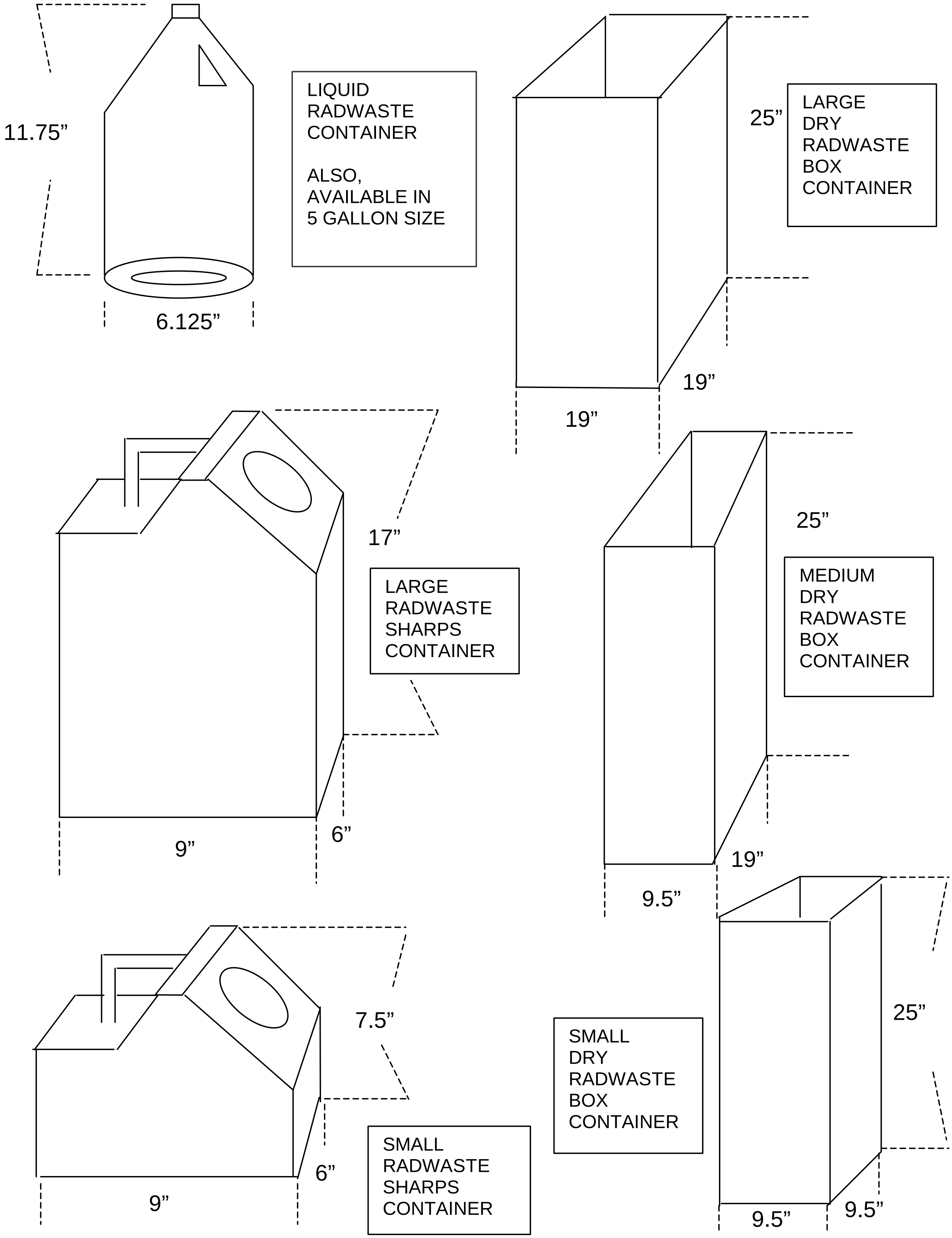
If there are any questions or special circumstances pertaining to the handling of radioactive waste, please call Environmental Services at 785-3551. Radioactive waste disposal is a service provided by the Office of Environmental Health and Safety.

Radioactive Waste Segregation Matrix

Waste Type	Class I: Isotopes with half-life ≤ 30 days	Class II: Isotopes with half-life > 30 days and ≤ 120 days	Class III: Isotopes with half-life >120 days	Class IV : H-3 and C-14
Dry Solid Waste (no lead, no sharps unless in sharps container, no animals)	Any combination of the above isotopes may be mixed in one box	Any combination of the above isotopes may be mixed in one box	Any combination of the above isotopes may be mixed in one box	Any combination of the above isotopes may be mixed in one box
Sharps (razor or scalpel blades, needles or syringes, broken glass, glass pastuer pipettes)	Any combination of above isotopes may be mixed in yellow sharps container	Any combination of above isotopes may be mixed in yellow sharps container	Any combination of above isotopes may be mixed in yellow sharps container	Any combination of above isotopes may be mixed in yellow sharps container
Liquids (No hazardous chemicals or controlled substances)	Any combination of above isotopes may be mixed in jug	Any combination of above isotopes may be mixed in jug	Separation by isotope preferred, contact OEHS if combining	Any combination of above isotopes may be mixed in jug
Liquids containing hazardous chemicals or controlled substances	Any combination of above isotopes may be mixed in jug	Any combination of above isotopes may be mixed in jug	Separation by isotope preferred, contact OEHS if combining	Any combination of the above isotopes may be mixed in jug
Animal Carcasses (No disposable instruments, needles or tubing) Wrap in kraft paper, freeze 24 hr minimum prior to pick-up, place in bag and seal	Keep extremely short-lived isotopes separate from other Class I isotopes	Any combination of above isotopes may be combined in bag	Separate by isotope	Any combination of above isotopes may be combined in bag
Stock Vials (Containing Stock Solutions)	Place each vial in small bag, seal, place in small box, and tag for pick-up	Place each vial in small bag, seal, place in small box, and tag for pick-up	Place each vial in small bag, seal, place in small box, and tag for pick-up	Place each vial in small bag, seal, place in small box, and tag for pick-up
Liquid Scintillation Vials Containing Non-hazardous approved fluors	Any combination of above isotopes may be mixed in drum	Any combination of above isotopes may be mixed in drum	Separation by isotope preferred, contact OEHS if combining	Any combination of above isotopes may be mixed in drum
Liquid Scintillation Vials with chemical hazardous fluors (i.e. toulene, xylene)	Any combination of above isotopes may be mixed in drum	Any combination of above isotopes may be mixed in drum	Separation by isotope preferred, contact OEHS if combining	Any combination of above isotopes may be mixed in drum

Class I: Isotopes with half-life ≤ 30 days
Class II: Isotopes with half-life > 30 days and ≤ 120 days
Class III: Isotopes with half-life >120 days
Class IV H-3 and C-14

Environmental Services
Radioactive Waste Container Sizes



APPENDIX - IX LABORATORY AND EQUIPMENT DECOMMISSIONING

Any time a lab unit vacates a space where they were previously using radioactive materials, a decommission survey must be performed by Radiation Safety. The decommission survey ensures that no contamination remains in the lab space upon arrival of the next occupant, confirms that all stock materials and wastes are handled appropriately, and confirms that equipment to be moved is decontaminated appropriately prior to the move.

When preparing to move, please adhere to the following steps to ensure the relocation gets handled as smoothly as possible:

1. Notify the Radiation Safety Section of intended move at 737-2121, giving the following information:

    a) Principal Investigator, Department, Contact Name, Phone and Fax Numbers
    b) Time and Date of the projected move
    c) Location of lab(s) being vacated
    d) Location of new lab(s), if any (Are you leaving the University?)

2. Determine and set the last day of active isotope use. Notify the Radiation Safety Section of that date. When <u>all</u> radioactive material use ceases, collect all radioactive waste and contact the Environmental Services Section at 785-3551 to have it removed. Consolidate all unwanted lead items (pigs, shields, sheets, etc.) into one area or container so they can be removed when radioactive waste is removed.

    <u>All</u> radioactive material not designated as waste must be removed from the lab either as:

    a) An Inventory *transfer within the workplace* (the material is relocated but never taken outside); or
    b) A Radioactive material *transfer within the University* (transported between University facilities using New Haven city streets); or
    c) A Radioactive material *transfer to another institution.* See the Radiation Safety Manual, appendix VII for complete details related to these modes of transfer.

        Note: For mode a) inform the Radiation Safety Section (RSS) of the transfer (785-3552). For modes b) and c) the Radiation Safety Section **must** be contacted (737-4128) to provide assistance and ensure your shipment is in compliance with all NRC and DOT regulations. Please remember, the requested decommission survey cannot begin until all radioactive material is removed.

3. Lab staff must perform both meter and wipe test surveys on all items that currently are, or PREVIOUSLY HAD been, used with radioactive materials. This survey must be documented for future reference. Items found to be contaminated with radioactive material must be cleaned and resurveyed until all removable contamination is removed (< 100 CPM). Documentation of decontamination surveys must also be maintained. The Radiation Safety Section **must** confirm that all radiation-related items are officially decommissioned prior to being removed from a Yale building. An official clearance will be issued for these items and should be made available to those concerned (movers, etc.)

4. After all equipment has been surveyed and removable contamination cleaned, lab staff must perform a routine monthly lab survey, which should include meter and wipe test surveys.

5. Yale Custodial Services or "outside" professional movers are often used to move heavy/bulky items (freezers, centrifuges, etc.). Any such item that was also radiation-related must be identified so it can be checked by Radiation Safety before movers arrive. Special arrangements must be considered when transferring frozen or refrigerated materials. When a lab is relocating within a Yale facility with no need to bring items outside of that facility, it is strongly recommended that responsible **lab** personnel survey and safely transport smaller radiation-related items such as pipetmen, vortex mixers, glassware, etc.

6. Plans to clean, paint, or otherwise renovate vacated labs may be formulated. However, under no circumstances will this type of work be permitted to begin until the Radiation Safety Section grants an official clearance of the respective labs.

7. The Radiation Safety Section representative assigned to monitor the relocation of your lab(s) will supply specific instructions to facilitate the move. Contact the representative as soon as possible. Transfer techniques, helpful advice, and information concerning official policy is available. The cooperative efforts by the Radiation Safety representative, lab workers, departmental staff and others are vital to ensure regulatory compliance, and above all, safe working conditions for all involved.

8. Be aware that the Radiation Safety Section often needs to be consulted prior to disposal of equipment. For example, liquid scintillation counters normally contain lead and a radioactive source that must be removed prior to disposal. Refrigerator/freezers contain Freon, which also needs to be removed prior to disposal. This will be removed by Physical Plant once RSS has issued a clearance for the refrigerator/freezer.

   Note: Any equipment or instrument that may have contained a chemical or biological material must be emptied completely, and when necessary, decontaminated appropriately by laboratory staff. If a Biosafety label is affixed to a piece of equipment slated for disposal or repair, lab personnel must decontaminate it and attached a "Biosafety Decommission Notice". Bio-decontamination **must** occur and the notice posted prior to RSS staff performing any surveys on these items.

APPENDIX - X SEALED SOURCES

Sealed sources are those radioactive materials that have been encapsulated or double enclosed to prevent leakage of the source contents. Often the radioactive materials within these sources are in a solid form or are electroplated onto metal within the source. Sealed sources can be in the form of discs, foils, seeds, wires or welded capsules.

Yale's NRC license states that the University may not acquire a sealed source or device unless the source or device has been registered with the U.S. NRC pursuant to 10CFR 32.210 or equivalent regulations of an agreement state. When choosing a source for a purpose, Principal Investigators need to verify that the source is of a registered design.

Testing of Purchased and Fabricated Sealed Sources

Each sealed source obtained from a vendor and containing byproduct material (other than tritium) with the half-life greater than thirty days, in any form other than gas, shall be tested for contamination and/or leakage immediately prior to use. Each sealed source fabricated within the University shall be tested for contamination and/or leakage immediately after fabrication. In addition to an initial test upon fabrication, the source will be stored for a period of seven days and retested prior to transfer to another Principal Investigator.

United States Nuclear Regulatory Commission (U.S.N.R.C.) Requirements

Each sealed source containing byproduct material, other than tritium, with a half-life greater than thirty days, and in any form other than gas, shall have the following:

1. Test for leakage and/or contamination at intervals not to exceed six months.

2. Tests shall be capable of detecting the presence of 0.005 microcurie of removable contamination.

3. Test wipings shall be taken from the sealed source or from the surfaces of the device in which the sealed source is permanently or semi-permanently mounted or stored and on which one might expect contamination to accumulate.

4. Alpha sources shall be tested at intervals not to exceed three months.

5. Results of tests shall be recorded and maintained for inspection by U.S.N.R.C. If the required tests reveal the presence of 0.005 microcurie or more of removable contamination the Radiation Safety Section shall notify the Principal Investigator and immediately withdraw the source from use, and shall cause it to be decontaminated and repaired if possible by the Environmental Service Section or to be disposed of.

Exceptions to Leak Test Requirements

No leak tests are required for the following:

1. Sealed sources containing tritium.

2. Sealed sources containing only a gas.

3. Sealed sources containing byproduct material with a half-life or less than thirty days.

4. Sealed sources in storage that are not more than 100 microcuries of beta and/or gamma emitting material or not more than 10 microcuries of alpha emitter material.

Sealed sources in storage that are not designed to emit alpha particles need only be leak tested every ten years. However, when these sources are removed from storage for use or transfer to another person, they shall be tested before use or transfer.

Principal Investigator Responsibilities

It is the responsibility of the Principal Investigator to provide source specific training to users and to ensure that leak tests are performed and that Radiation Safety is notified of all such sources requiring leak tests. Contact Radiation Safety (785-3550) for details.

Radioactive Source Use Guidelines

Although most radioactive sources are used for the purpose of calibrating detector systems or instruments, use is not limited to that purpose only. There are many possible uses, which result in a variety of source configurations and handling situations. There are two generic categories of sources. There are sealed sources and unsealed [non-sealed] sources. A sealed source is one that meets regulations describing encapsulation of the radioactive material. Often this encapsulation involves 2 or 3 layers of metal covering. Such a sealed source represents a high degree of physical containment, so that one has to severely damage the sealed source capsule to reveal the radioactive materials inside. An example of a sealed source is an ^{241}AmBe-neutron source. There are also unsealed sources and an example of such a source is one designed to emit alpha particles. An alpha emitting radionuclide may be electrodeposited on a substrate. Such a source may have a very thin window in the source to contain the radioactive material yet allow alpha or low energy emissions to penetrate. The window may only be a few microns in thickness. A similar type source may have a thicker window to "stop" the alpha particles, with the source designed to function only as a gamma source. Because of their design, handling of unsealed sources must be gentler and in many cases more cautious than sealed sources. Care must be taken not to damage the window or other fragile protective coatings. Some of the following will apply to all sources and some specifically to unsealed sources. We hope these guidelines aid in keeping radiation exposure from source use **A**s **L**ow **A**s **R**easonably **A**chievable.

All Sources:

Your use of a radioactive source may require the use of a personal dosimeter [film badge or TLD.] The purpose of the dosimeter is to record your external radiation exposure. In some cases, a "finger ring" dosimeter may be required. This would be necessary to record extremity exposures (hands). For further information, contact your supervisor or the Radiation Safety Section.

It is important to be aware of the *dose rate* close to the surface of the source and at a typical working distance. This may be available from manufacturers data, but it is desirable to confirm this by measurement or calculation. If this determination is made by measurement be certain the proper instrument was used and its efficiency was known.

Be certain of the *isotope and quantity* of the source. Will use of this source provide you with the emission or information you need? The *emission characteristics* are an important factor in source selection. An ^{241}Am source designed to emit gammas would be of little use if one were looking for alphas. Making the right selection the first time minimizes handling of sources, thereby reducing your exposure.

Be aware of the *environment* to which you subject the source. Corrosive atmospheres, solvents, pressures other than atmospheric can damage the source. A damaged source may release radioactive materials, resulting in radioactive contamination in unexpected places.

Be certain to report any *damaged sources* to your principal investigator. We also require reporting damaged sources to the Radiation Safety Section. If a source does not seem to perform as it has in the past, it is possible the source has been damaged. Do not use sources that are possibly damaged. Verify that there is no damage to the source. Check with other users, your supervisor or your PI. Contact Radiation Safety if necessary. **Do not place the source back in storage if damaged or if you suspect damage!** If a source has been damaged, an inspection of the source, a survey of the use area and a check for personal contamination by Radiation Safety may be required.

All sources must be stored in a secure location where only authorized users have access to these materials. Sources in use must be "attended" by the user or secured, and then placed back in locked storage when use is complete.

Old, unusable or decayed sources should be disposed of through the Environmental Services Section as radioactive waste.

Unsealed Sources:

Unsealed sources vary in construction from the electro-deposited source to a solid radioactive metal disk with a mylar cover. The degree of physical containment of the radioactive material varies considerably. A source can even have rugged encapsulation, but unless it registered with the US Nuclear Regulatory Commission under 10CFR32.210, [or an Agreement State where it was manufactured] it should be regarded as an unsealed source.

Because of the construction of most unsealed sources, additional caution in handling is required. It is important to be certain of the active side of the source as well as the actual area on the active side where the RAM is located. Safe handling of the source depends on prior knowledge of this information. Physical contact with the active side of the source could result in damage to the source and possible personal contamination or excessive external exposure. Such mishandling could also render a source useless. Applying tape or any other adhesive material could destroy the source or render it useless, particularly if one is not aware of the active side of the source.

In many cases it can be confusing which side of a source is active. The amount of radioactive material deposited on a substrate may be a layer that is too thin to see. There may be a layer of thin covering over the radioactive material that is difficult or impossible to see. Without manufacturers design data, and depending on source construction, it may be very difficult to determine the active side of a source. Sources should be marked or design information posted so that users can readily verify active side and other specifications of the source. The bottom lines is that the user must know the source, seek out source information and see their supervisor for source specific training. Call Radiation Safety with questions or help obtaining technical information.

APPENDIX - XI X-RAY DIFFRACTION RADIATION SAFETY INFORMATION

The following information should be read by all users of x-ray diffraction units. The form at the end of this section should be signed by each user and responsible Principal Investigator, and forwarded to Radiation Safety.

I. Hazards of Operating Machine Sources of X-Rays

The radiation from x-ray machines can be very dangerous, and such danger should not be minimized. On the other hand, there is no reason to be afraid to operate these machines after receiving proper training and instructions. The operator of an analytical x-ray machine should never become complacent or overconfident about the potential danger from an x-ray beam.

Numerous safety devices may be provided, but the user should not depend too heavily on these safety devices lest he become overconfident. If a safety device should fail unnoticed, serious injury may result. Adequate safeguards must be provided, but these can never replace constant vigilance and alertness to possible danger. Proper training in the operation of these machines should teach the nature of the hazards so that the user can be properly alert and vigilant.

The wavelengths of the x-rays used most commonly in x-ray diffraction and fluorescent x-ray spectroscopy fall in the range from approximately 0.5 to 10Å. These are so-called "soft" x-rays which are readily absorbed in matter. A thickness of only a few mm or less of Al, Fe, or Pb is required to reduce the intensity of the transmitted beam to 1/10 that of the initial intensity even for x-rays with a wavelength of 0.5Å. The 1.54Å wavelength corresponds to CuKa radiation, and 1.93Å is the wavelength of FeKa radiation. These are commonly used sources in x-ray diffraction work.

It is apparent that only relatively thin layers of shielding are required to protect against this radiation, but it is this same property that makes these x-rays very dangerous. They are highly absorbed in soft tissue, and severe burns can result from exposure of the hands, arms, skin or eyes to the direct or diffracted beams. The maximum permissible dose of radiation for various parts of the body are shown in Table I. For comparison, x-ray intensities that may be obtained with high-power tubes and strongly diffracting crystals are also shown in Table I. It is apparent that a dose of 100 to 500 times the permissible yearly dose may be obtained from a 1-second exposure to the most intense direct beam. Even a strong diffracted beam can deliver the maximum permissible yearly dose to the eye in less than 10 minutes.

II. Biological Effects of Intense X-Ray Beams

It is possible to provide a general classification of the kind of changes that ionization radiation can produce in skin. It is useful to categorize these effects into three areas.

1. Reversible changes.
2. Conditional reversible changes.
3. Irreversible changes

A. Reversible Changes

The most common and earliest reversible change is the production of reddening of the skin or erythema. If the dose and energy is low enough that most of the radiation is absorbed in the superficial layers of the skin, reddening occurs, then disappears apparently with no future effects.

Another reversible change is the loss of hair or epilation. It is possible to give a dose of radiation that will stop cell division in the epithelial cells so that hair ceases to grow temporarily and falls out. With a low dosage, the hair will begin to grow after a period of time, with no apparent permanent ill effects.

A third system that shows reversible effects are the sebaceous glands (oil-producing glands in the skin) which are temporarily affected to produce less sebum (oil secretion of these glands in the skin).

B. Conditional Reversible Changes

Pigmentation of the skin is not a totally reversible change. If a large area of skin is irradiated, erythema and pigmentation will occur with the pigmentation eventually fading. It has been shown that the resulting skin is not normal and has some "memory of the injury." Future doses of the same area do not produce the same skin response.

C. Irreversible Changes

If enough radiation of the proper energy is absorbed in the skin this will result in permanent destruction of either hair or sweat glands, or whole skin, with a resulting scar. The irreversible changes are categorized in the heading of:

1. Radiation Dermatitis
2. Chronic radiation dermatitis
3. Radiation cancer

A summary of the various effects to be expected after given acute dose to low energy x-rays and the time of exposure to receive the dose in the beam are given in Table II on page 84.

Sources of Exposure

1. The primary beam.
2. Leakage of primary beam through cracks in shielding.
3. Penetration of primary beam through shutters, cameras, beam stops, etc.
4. Secondary emission (fluorescence) from a sample or shielding material.
5. Diffracted rays from crystal.
6. Radiation generated by rectifiers in the high voltage power supply.

TABLE 1
NRC OCCUPATIONAL EXPOSURE LIMITS*

	YEARLY LIMIT (mrem)
WHOLE BODY	5000
SKIN OF THE WHOLE BODY	50000
EXTREMITY	50000
LENS OF EYE	15000
MINORS (PERSONS UNDER THE AGE OF 18)	500
FETAL EXPOSURE	500/Nine months

*Note: State of Connecticut exposure limits vary slightly. For more information contact Radiation Safety.

TYPICAL X-RAY BEAM INTENSITIES

Primary Beam: 400,000 Rem/min., 2.4×10^7 Rem/hr

Diffracted Beam: 80 Rem/hr.

It should be noted that in x-ray diffraction both the primary beam and the diffracted beam are small and well collimated, which increases the possibility of receiving severe burns on very localized areas of the fingers, hands, eyes, or arms if inadvertently exposed. Leakage of the primary beam or scattered radiation through cracks or small openings in the shielding likewise may give rise to small but intense beams which may escape detection in general area radiation surveys unless the survey is carried out carefully. The penetration of the primary beam through shutters on commercial equipment may result if the shutter becomes defective or does not close properly. Improperly designed shielding can itself be a hazard if it excited to fluorescence and the radiation is allowed to scatter into the room. The rectifiers in the high-voltage power supply constitute a frequently unsuspected source of hazardous radiation. When they become gassy they function like x-ray tubes, and due to the high voltages that may be impressed across them, they can emit penetrating radiation. It is essential that adequate shielding be provided around the rectifier tubes to prevent this radiation from escaping into the room.

TABLE II

Effect	Comments	Dose, Rem	Primary Beam *Expose time, sec
erythema	Appear in one day , disappears and recycles -- lasts 40-50 days	500-800	0.75-0120
epilation		350 Temporary 1200 permanent	0.0525 0.180
acute dermatitis		3000-4000	0.45 - 0.60
chronic radiation dermatitis	Over Time, ulceration, tumors, thin skin	Thousand of rem over many years in small doses.	NA
skin cancer	Median time between x-ray exposure and production is 10-15 years.	Receive small doses over a long period of time to get a total large dose. 50-100 rem/wk. for 5-7 years.	NA

* assuming an in-beam dose rate of 400,000 rem/min.

IT SHOULD BE POINTED OUT THAT A ONE (1) SECOND EXPOSURE OF AN EXTREMITY IN THE PRIMARY X-RAY BEAM COULD RESULT IN A DOSE OF OVER 6,000 REM!

III. Precautionary Measures

General precautionary measures to be taken to protect against accidental exposure to x-radiation are:

1. Effective shielding
2. Check tubes or shield tubes in high voltage rectifier
3. Interlock switches and warning lights
4. Radiation monitoring, film badges
5. Physical exam of any suspected injury
6. Radiation surveys by the Radiation Safety Section and operator.

To be effective, the shielding must prevent any stray radiation from escaping into areas where it can be intercepted by personnel in the room. Care should be taken to avoid cracks or small openings which may go unnoticed.

Tube status indicators should be provided both at the on-off switch and near the tube head so that the operator will be reminded whenever the x-ray beam is on. In addition, a light or other signal should be provided to indicate when the shutter is open, and this should be augmented by interlock switches and lights or manual control devices that will prevent access to the beam area when the shutter is open. It is advisable to conduct a regular maintenance program scheduled and checked by the Principal Investigator in order to insure that these safety devices are always in proper working order.

Radiation monitoring is of two types. On the one hand, the intent is to determine how much radiation a person may have received in a given period of time. For this purpose a film badge is worn, but this usually indicates only the general level of radiation in the room, or the level of whole-body radiation. Radiation surveys around the tube head and associated equipment should be conducted by the operator and radiation safety personnel to check the adequacy of the shielding. This should be done periodically with a detector which is sensitive to the x-ray wavelengths being used or generated. A survey should also be conducted whenever the geometrical arrangement or design of the equipment is changed in order to accommodate new experiments or procedures. Records should be kept of the survey results.

Beam detection with fluorescent screens should be done with the screen placed on a long device to insure that no exposure to the primary beam is possible. For experiments taking long periods of time, the operator should leave the area, securing it for unauthorized access.

IV. Accidents

If you feel you may have been exposed to the primary beam, or if you feel conditions on your unit have changed significantly, you should call Radiation Safety at 785-3550. If you cannot reach anyone in Radiation Safety, call Campus Police at 111 or 432-4400 (accidents and emergencies only). Campus Police will then contact the appropriate Radiation Safety personnel.

- -

Detach, sign and mail to: Radiation Safety
135 College Street
New Haven, CT 06510

I have read the contents of this x-ray diffraction radiation safety guide and have been instructed as to the proper operation procedures in using the unit(s) located in:

____

User Signature:____
SIGNATURE and TYPED NAME

Trainer: ____
SIGNATURE and TYPED NAME

Responsible Principal
Investigator Signature:____
SIGNATURE AND TYPED NAME

Date:____

V. X-ray Diffraction Unit Safety Guidelines

AUTHORIZED PERSONNEL ONLY - You must have department approval and proper equipment orientation training prior to using x-ray equipment. A Radiation Safety information handout is available as a resource. See the equipment supervisor or call the Radiation Section at 785-3550.

- To insure your safety, do not attempt any unauthorized repair of x-ray unit.
- Do not allow hands, fingers or other body parts to enter the x-ray beam.
- Be sure the beam is off and shutter is closed prior to sample changing or other activity. Check all warning lights prior to placing hands near the beam line. Use a GM radiation survey instrument to confirm "beam off" conditions.
- Use the shielding and interlocks provided. Do not bypass interlocks.

X-ray units need routine shutter maintenance to prevent shutter failure and resulting safety hazard. See equipment supervisor.

Should any safety related interlock or device fail, the unit should be taken out of service until such time as effective repairs have been made. Failure of beam shutter(s) must be reported to the Radiation Safety Section. A heath physicist may physically inspect the unit prior to use, after such repairs have been made. If you are having problems with the equipment, ask for assistance.

In case of emergency or accident notify your supervisor and Radiation Safety immediately at 785-3555. Prevent further use of the unit until a safety evaluation is done.

APPENDIX - XII MEDICAL OR VETERINARY X-RAY EQUIPMENT

All University owned x-ray equipment used for clinical reasons (i.e. x-ray examinations on humans) is inspected by Radiation Safety to insure proper functioning. Shielding, personnel dosimetry requirements and safety procedures are handled by Radiation Safety. Only properly trained, certified personnel may expose humans using medical x-ray equipment.

Other x-ray equipment may include portables, C-arms, therapy units or diagnostic x-ray units. Use of such veterinary or cell irradiation x-ray equipment may also require shielding to protect persons in the surrounding area. Personnel dosimeters are generally required for personnel using veterinary x-ray equipment. Safe use of the equipment requires proper equipment use training. Safety procedures are supervised by Radiation Safety.

Radiation Safety should be notified as soon as any purchase of x-ray equipment is planned so that shielding and other safety requirements can be determined. X-ray equipment must be registered with the State of Connecticut Department of Environmental Protection. Any fees are the responsibility of the Principal Investigator.

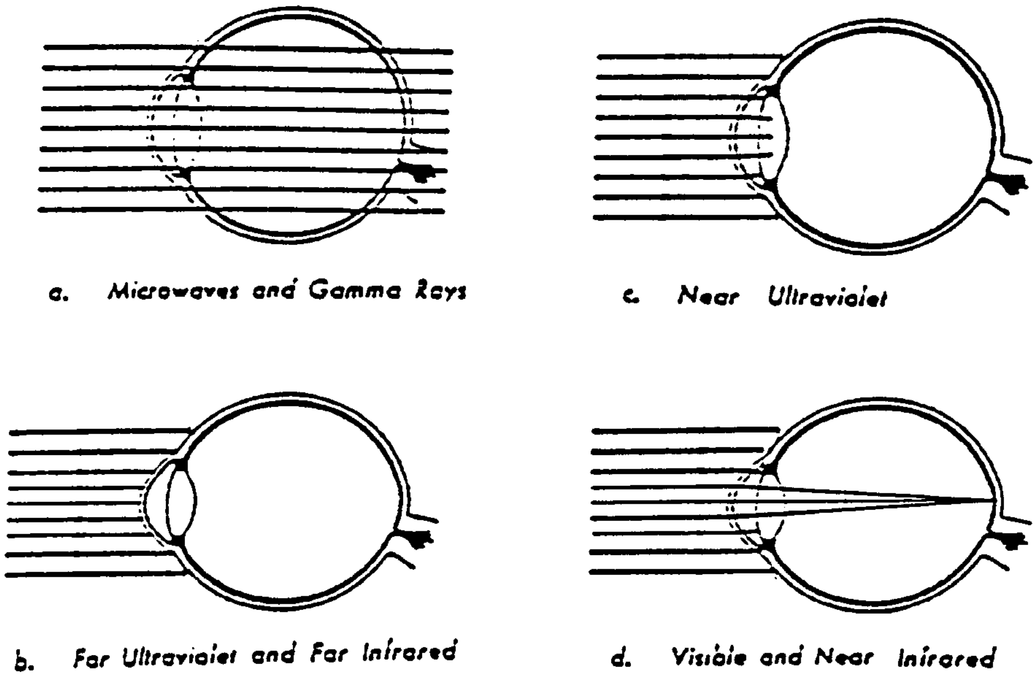
For further information about State of Connecticut regulations and safe use of x-ray equipment, call Radiation Safety.

APPENDIX - XIII LASER SAFETY AND LASER POINTER USE POLICY

The laser is a device which produces a very intense and very narrow (collimated) beam of electromagnetic radiation in the frequency range of 200 nm (nanometers,1 x 10^{-9} meters) to 1 mm. This radiation is generally in the form of intense visible light. Because laser light is not an ionizing type of radiation (i.e., not like gamma rays, x-rays, or beta particles), interaction with the body is generally at the surface. The eye and the skin are critical organs for laser radiation exposure, and the resultant effects vary depending on the type of laser (frequency or wavelength of the radiation) and beam energy output. Laser energy of the proper wavelength and energy may be focused by the lens of the eye onto the retina causing severe damage. If laser radiation is of high enough energy, skin burns may also result if extremities or other body parts are placed in the laser beam. The following table summarizes the various regions of the electromagnetic spectrum produced by laser and the organs of concern if exposure occurs.

LASER OUTPUT WAVELENGTHS AND ORGANS PRIMARILY EFFECTED

ELECTROMAGNETIC SPECTRUM REGION	WAVELENGTH RANGE	ORGAN EFFECTED
Ultraviolet	200 to 400 nm	Cornea, Lens, Skin
UV-C	200 to 280 nm	All absorbed in Cornea and Conjunctiva
UV-B	280 to 315 nm	Almost all absorbed in Cornea-Conjunctiva Cataract formation
UV-A	315 to 400nm	All absorbed in lens. Cataract formation
VISIBLE LIGHT	400 to 780 nm	Retina
NEAR INFRARED (NIR)	780 nm to 1.4um	Retina, Lens, Skin
MID AND FAR IR		
IR-B	1.4 - 3.0 um	Cornea and Skin
IR-C	3.0 um to 1 mm	Cornea and Skin



Schematic diagram of the absorption of electromagnetic radiation in the eye.

Figure 1

The drawings shown in **Figure 1** indicate the absorption of electromagnetic energy by the eye at various frequencies. The most damaging frequency band is the "visible" as the lens has the ability to concentrate the laser energy incident in the cornea by 100,000 to 200,000 times producing a very intense spot on the retina (see d. in the figure).

In addition to the hazards described above, laser systems may involve high voltage hazards, toxic gas or vapors, fire hazards, and depending on experimental set up may involve microwave and/or x-radiation hazards. All of these hazards must be addressed for the overall safe operation of a laser installation.

I. Laser Classification Levels

The American National Standards Institute classifies laser systems into four classifications. These classifications are based on the potential for the direct beam or reflected beam to cause biological damage to the eyes and/or skin. Lasers are classed as:

CLASS I: Considered to be incapable of producing biological damage to eyes or skin.

CLASS II: "Low power systems", under certain conditions may be hazardous to eyes. Must have caution label affixed to laser.

CLASS IIIA: Intermediate power systems, require labeling and controls

CLASS IIIB: "Medium power systems", requires labeling and physical control measures to prevent viewing of direct and reflected beam.

CLASS IV: "High power systems", requires labeling and physical controls to prevent eye or skin contact with direct or reflected beam, and also with the diffusely reflected beam.

Embedded systems:

Class 2, 3 or 4 lasers or laser systems contained in a protective housing and operated in a lower classification mode may be classified at a lower classification. Specific control measures may be required to maintain the lower classification. For embedded systems that are non-commercial design and construction, the University LSO shall determine the classification.

For the purposes of laser safety, a direct laser beam which has been deflected from a mirror or polished surface is considered to be as intense as the direct beam. Laser beams which hit flat or non-mirror like surfaces are considered to be diffuse and the diffusely reflected beam is not as intense or as well defined as the direct beam.

II. Safety Guidance For Laser Operation

The guidelines which follow may or may not be applicable for each type of laser installation. Because the laser hazard is related to the wavelength, intensity, and intended use of the laser, the guidelines may be relaxed accordingly. For example, a class IV laser placed into a properly constructed enclosed beam path system may be reclassified as class I or II. The required safety measures would then be reduced.

For all lasers, use the minimum amount of laser radiation possible to accomplish the experimental objective. Adjust beam height so that it is at a level OTHER THAN that of a seated or standing person.

DIRECT EXPOSURE OF THE EYE BY A LASER BEAM SHOULD ALWAYS BE AVOIDED WITH ANY LASER, NO MATTER HOW LOW THE POWER.

A. CLASS I LASER CONTROL MEASURES

1. Control measures or warning labels are not required, although needless direct exposure of the eyes should be avoided.

B. CLASS II LASER CONTROL MEASURES

1. An appropriate warning label must be placed on the housing.

2. Do not stare into the beam or allow other persons to do so.

C. CLASS III A or B LASER CONTROL MEASURES

1. The laser must have a protective housing such that laser light emerges from the aperture only.

2. A Key switch interlock system should be used to prevent unauthorized use of the laser.

3. The direct or mirror-reflected beam should not be viewed with the naked eye or with optical instruments such as telescopes.

4. Do not align the beam with the naked eye.

5. A beam stop must be provided to adequately stop the beam with the absence of scattered light emission.

6. Laser goggles may be necessary. Be certain that the goggle in use is appropriate both in the attenuation factor provided by the goggle and that the goggle is for the proper wavelength. LASER GOGGLES MUST BE MATCHED TO THE WAVELENGTH(S) OF THE LASER SYSTEM(S) BEING USED! Be aware of the dangers that reflected lasers can pose. In addition to mirrors, many smooth surfaces can reflect lasers.

7. Spectators must be limited.

8. The laser system should be installed in a sole use laboratory and the door kept closed during operation. The door should be labeled.

9. Be certain that scattered laser radiation is not escaping through a window to the outside.

10. Label high voltage areas and investigate for other associated hazards.

11. Eye examinations may be required prior to the use of such laser systems.

D. CLASS IV LASER CONTROL MEASURES

Call the Radiation Safety Section at 785-3550 for additional requirements.

1. All of the measures outlined in 3. above should be followed in addition to the measures below.

2. Goggles are required when such systems are in operation.

3. Spectators are prohibited.

4. The entrance to such areas must be interlocked such that entry shuts the beam down.

5. Such systems must be in sole use areas.

6. Access to such lasers shall be controlled by keyed access to both the room and the power panel to the laser. Such key will be kept in the possession of the Principal Investigator and access will be the Principal Investigator's responsibility.

7. Eye examinations are required prior to the use of such laser systems.

8. The Radiation Safety Section may institute additional control measures as deemed necessary for the safe operation of the laser.

Responsibilities of the Principal Investigator

1. To read and comply with University Laser Safety procedures.

2. To be familiar with content of LIA Laser Safety Guide [Class 3B , 4] and ANSI Standard [Class 4].

3. To train all users about specific safe use of laser.

4. To provide adequate supervision of all laser users.

5. Notify OEHS of all laser users names [Class 3B and 4].

6. To comply with medical surveillance program.

7. To have written standard operating procedures for use of Class 3B and Class 4 lasers.

8. To submit a copy of SOP's to OEHS. Notify OEHS of any changes in COP in writing.

9. To notify OEHS of any changes to enclosed laser systems.

10. To post appropriate signage.

11. To report accidents/injuries to University Health Services and OEHS within 24 hours.

Responsibilities of Individual Users

1. To read and comply with University Laser Safety procedures.

2. To be familiar with the content of LIA Laser Safety Guide [Class 3B,4] and ANSI standard [Class 4].

3. To participate in medical surveillance program.

4. To comply with written SOP established by Principal Investigator.

5. To NOT permit entry by ancillary services personnel into a room or area where a Class 3B or 4 laser system is operating.

6. To report all accidents or injuries to PI, University Health Services and OEHS within 24 hours.

7. To avoid working alone with high voltage or energy storage [capacitor banks] systems.

8. To see PI for any specific laser training, questions , supervision and before modifying the system.

The laser safety program is a part of the University Radiation Safety program. As such, laser use is under the general direction and authority of the Radiation Safety Section and the Radiation Safety Committee.

III. Laser Pointer Use Policy

Laser pointers have generated much publicity and concern over the last several years. There have been documented injuries related to the misuse of laser pointers. Part of the problem is the marketing of laser pointers as toys. They are not toys.

Laser pointers are generally safe when used by adults for the intended purpose of highlighting areas of interest during a lecture or presentation. The use of laser pointers at Yale University should be under the supervision of a responsible adult.

Normally one blinks in response to bright light and it is this response that protects one from damage to the eye. Intentional suppression of the response may result in possible eye damage. Momentary exposure to the light from a laser pointer may cause temporary "flash blindness". While not dangerous in itself, it may be dangerous if the exposed individual is involved in vision critical activity such as driving or operating machinery.

Laser pointers should be labeled as a "Caution Class II " or "Danger Class IIIA" laser product. The labels are quite small. Laser pointers, which do not have a caution or danger label on it identifying the class, are not acceptable for use at Yale. Please be aware that some imported laser pointers may not be labeled. Such lasers may produce power levels that exceed acceptable power levels for laser pointers. The best laser pointers to select are those bearing Class II labels.

Any laser pointer altered or modified in such a way as to increase power output or output wavelength is no longer acceptable for use as a laser pointer at Yale.

Laser Pointer Tips

- Never shine a laser pointer at anyone. Use must be limited to inanimate objects.
- Do not allow unsupervised use by minors. Laser pointers are not toys.
- Do not point a laser pointer at mirror-like surfaces. A reflected beam can act like a direct beam on the eye.
- Do not purchase a laser pointer if it is not properly labeled. If you receive an unlabeled laser pointer, return it to the vendor. Request one with proper labels.
- Do not modify a laser pointer in any way.

If you have any questions regarding laser pointers, laser pointer use or lasers in general, please contact Laser Safety at 737-2832 or 785-3550.

APPENDIX - XIV   ELECTRON MICROSCOPES

Electron microscopes produce very low level x-radiation and usually pose no direct hazard to the operator. It is rare to detect x-rays in front of these units, most leakage being confined to the back of the column and directed away from the operator. This is especially true for electron microscopes manufactured since the early 1980's. Personnel dosimeters are not required for electron microscope operators. If you have an older electron microscope or are concerned about an electron microscope, contact Radiation Safety to arrange for an x-ray leakage survey. Notify Radiation Safety about disposal or purchase of electron microscopes. Note: Many electron microscopy labs have uranyl acetate compounds present. Please see Appendix XXI of this manual for information regarding the safe use of this naturally occurring radioactive material.

APPENDIX - XVI   ACCELERATORS

Yale University has a number of research accelerators that may be used by Yale researchers. These include the ESTU Tandem Accelerator located in the Wright Nuclear Structure Laboratory. Because the radiation hazards are unique to accelerators, a separate Accelerator Safety Manual is available to all users. Contact your Principal Investigator or the Radiation Safety Section to review the Accelerator Safety Manual. Accelerator safety training is provided by the Principal Investigator as well as by Radiation Safety.

The ANSI Standard "Radiological Safety in the Design and Operation of Particle Accelerators" is also available from Radiation Safety. For further information about the use of accelerators at Yale University, contact Radiation Safety.

APPENDIX - XVII RADIOACTIVE FOILS IN GAS CHROMATOGRAPH EQUIPMENT

All gas chromatography units, in which radioactive materials are to be used, are regulated as follows: Each cell containing a radioactive foil must have a label showing the radiation caution symbol with the words, "Caution - Radioactive Material," and the identity and activity of the radioactive material.

Individuals using radioactive compounds in gas chromatography equipment should vent the cell-exhaust through tubing into a hood or approved trap. This procedure will avoid contamination of work areas from the release of radioactive labeled samples introduced into the system or from the accidental overheating of radioactive foils in the cells.

The Principal Investigator will be responsible for periodic leak tests and storage of radioactive foils when not in use.

APPENDIX - XVIII USE AND DISPOSAL OF EQUIPMENT CONTAINING RADIOACTIVE SOURCES

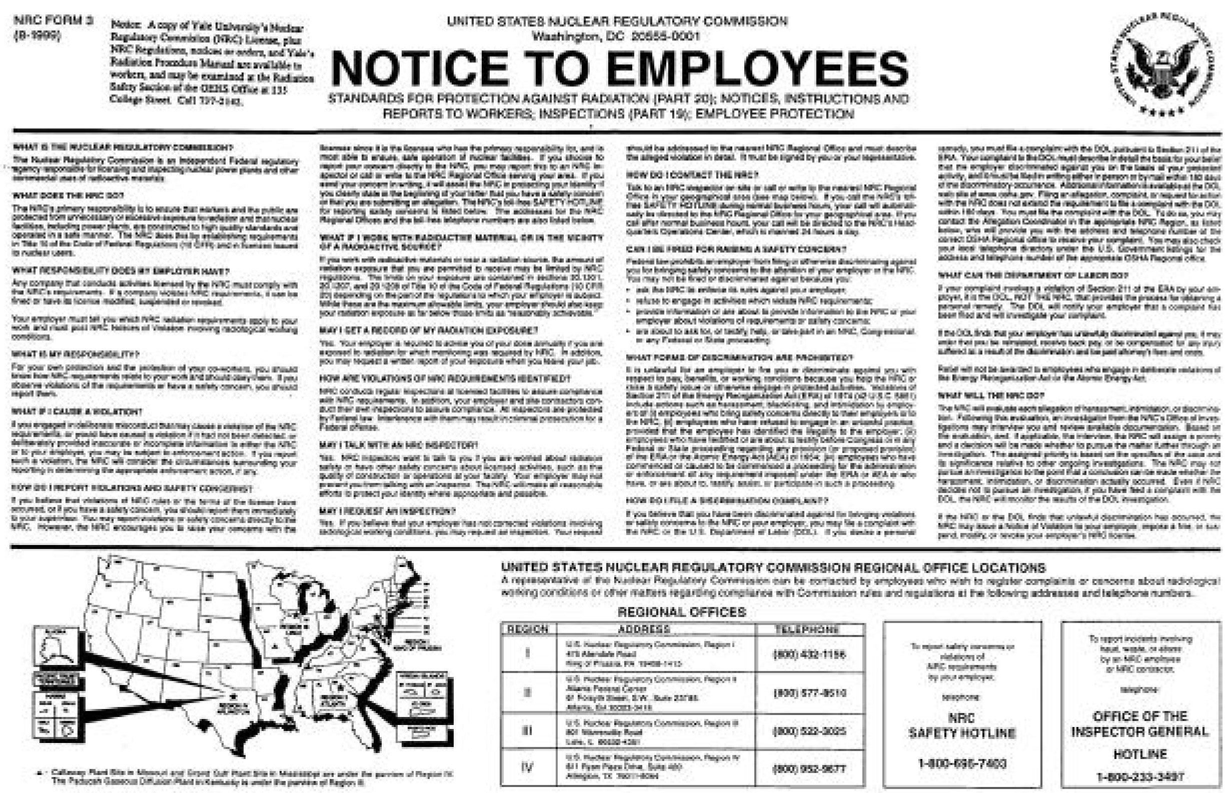
A number of different pieces of equipment used in a research setting may contain radioactive sources. Liquid scintillation counters, gamma counters, and gas chromatographs are some examples of equipment commonly containing radioactive sources.

Labs possessing (or newly acquiring) equipment with radioactive sources should inform Radiation Safety of the presence of this equipment. These pieces of equipment should be labeled with a sticker stating “This unit contains a radioactive source. Contact the Radiation Safety Section prior to disposal”.

The transfer or disposal of such equipment must be coordinated through the Radiation Safety Section. Never dispose of a piece of equipment containing radioactivity prior to contacting Radiation Safety. Call 737-2121 for assistance in moving or disposing of these items.

APPENDIX - XVIV NRC FORM 3

This form is printed and distributed by the Nuclear Regulatory Commission. The NRC updates and revises the form on a regular basis. The most recent revisions have been posted in numerous locations (radioactive material use labs, hallways, department bulletin boards and Safety Notice Bulletin boards) throughout the University. Please consult one of these locations for the most current version, or call Radiation Safety at 785-3550.



NRC FORM 3
(8-1999)

UNITED STATES NUCLEAR REGULATORY COMMISSION
Washington, DC 20555-0001

NOTICE TO EMPLOYEES

STANDARDS FOR PROTECTION AGAINST RADIATION (PART 20); NOTICES, INSTRUCTIONS AND REPORTS TO WORKERS; INSPECTIONS (PART 19); EMPLOYEE PROTECTION

UNITED STATES NUCLEAR REGULATORY COMMISSION REGIONAL OFFICE LOCATIONS

A representative of the Nuclear Regulatory Commission can be contacted by employees who wish to register complaints or concerns about radiological working conditions or other matters regarding compliance with Commission rules and regulations at the following addresses and telephone numbers.

REGIONAL OFFICES

REGION	ADDRESS	TELEPHONE
I	U.S. Nuclear Regulatory Commission, Region I	(800) 432-1156
II	U.S. Nuclear Regulatory Commission, Region II	(800) 577-8510
III	U.S. Nuclear Regulatory Commission, Region III	(800) 522-3025
IV	U.S. Nuclear Regulatory Commission, Region IV	(800) 952-9677

NRC SAFETY HOTLINE
1-800-695-7403

OFFICE OF THE INSPECTOR GENERAL HOTLINE
1-800-233-3497

APPENDIX - XX UNIVERSITY EMERGENCY PLAN FOR RADIATION ACCIDENTS

Emergencies involving radioactive material at the University may be classified into three general categories. The actions required on individuals involved vary according to the accident classification. The three accident categories are given in the following table along with the most immediate action that should be taken with appropriate phone numbers. Also included is the section of this appendix which should be consulted for more detailed information.

RADIATION ACCIDENT CLASSIFICATIONS

Emergency	Immediate Actions	See Section Number of this appendix
LIFE THREATENING INJURY and Radioactive Contamination	*** CALL 111 *** (Campus Police) ** CALL 785-3555 ** (Radiation Safety)	I then III (on following pages)
MINOR INJURY and Radioactive Contamination	Give first aid if possible, confine spread of contamination ** CALL 785-3555 ** (Radiation Safety) *** CALL 111 *** (Campus Police)	II then III (on following pages)
NO INJURY with release, spill and/or body contamination	Restrict area ** CALL 785-3555 ** (Radiation Safety) After Hours *** CALL 111 *** (Campus Police)	III (on following pages)

I. Life Threatening Injury and Radioactive Contamination

It is imperative in all cases of life threatening injuries that life saving actions be taken immediately. Generally, only after the victim has been attended to medically should one be concerned with the radiation hazards one finds at Yale. An external exposure to a radiation source will not make the victim radioactive or "contaminated". Contamination will result only if a powder, liquid, or other similar dispersible material containing radioactive material is accidentally spilled on the victim. If radioactive contamination is not involved the victim should be treated as any other emergency case. It is very important to know if radioactive contamination is involved as the presence of radioactive contamination significantly alters the way in which the Yale-New Haven Hospital Emergency Room receives the patient. The following guidelines should be followed when an accident occurs in a radioactive materials laboratory which involves life threatening injury and radioactive contamination.

A. Assess the medical condition of the victim and render first aid as required. Try to determine the extent of the injury. Prevent unnecessary persons from entering the area of a radiation hazard.

B. Call or have a co-worker call the Campus Police at 111 or 432-4400.

C. The following information should be relayed to the police officer:

1. Victim's name
2. Victim's location - building and number
3. Nature of injuries
4. Your name and phone number
5. The radioactive material present on the victim and approximate quantity.

D. The Campus Police may call back to verify your call. Campus Police will call RSS.

E. Await the arrival of emergency personnel. If possible, send a co-worker to meet the ambulance in order to escort emergency medical personnel to the accident scene.

F. Remove contaminated items and clothing from the victim if the medical condition is such that these actions would not do further harm to the victim.

G. If time permits, place absorbent matting on the floor to provide a non-contaminated path for the emergency crew.

H. Accompany the victim to the emergency room. You may be able to provide valuable information to the medical team attending the victim.

II. Minor Injury and Radioactive Contamination

Accidents involving radioactive contamination and injuries which are not life threatening may be treated with less urgency. However, as in the case of very serious injury, you must assess the medical condition and give first aid immediately. Once it is determined that the injury does not require transport to the Yale-New Haven Hospital Emergency Room the following guidelines should be followed in responding to such emergencies.

A. Evaluate the nature of the injury. Give first aid immediately.

B. Wear rubber gloves and sponge and/or flush the contaminated area if possible. Be careful not to spread contamination.

C. **During normal working hours contact:**

RADIATION SAFETY 785-3555
OR
CAMPUS POLICE 111 or 432-4400

During off hours contact:

CAMPUS POLICE 111 or 432-4400

D. Give details of the accident, the radioactive material present, your location, your name, and your phone number.

E. Radiation Safety will provide you with instructions for dealing with the accident.

F. If it is necessary to transport an individual to the Yale-New Haven Hospital Emergency Room the New Haven Fire Department will provide the transportation. The exact details of this transfer will depend on the extent of the injuries and radioactive contamination present. An individual with a minor injury should not be taken to the hospital emergency room without first contacting Radiation Safety for guidance.

G. Remove any contaminated clothing and decontaminate as instructed by Radiation Safety.

H. Prevent the spread of contamination by isolating and sealing the accident area. Keep people out! Shut down ventilation if possible.

III. No Injury with Release, Spill and/or Body Contamination

A. Extreme Hazards - high radiation levels (100 mrem/hr) or the possibility of airborne contamination from dry or volatile radioactive materials.

1. Evacuate the laboratory immediately; close and lock the door and/or stand guard to prevent entrance; during normal working hours, immediately contact Radiation Safety and give details of the accident. (Phone 785-3555).

2. During off hours, evacuate laboratory, close and lock the door, call Campus Police (phone 111 or 432-4400) and give details of the accident including phone number and await instructions. The Campus Police will contact Radiation Safety personnel. Radiation Safety personnel will then contact the individual and give instructions.

3. If you have to leave the area to call Radiation Safety or Campus Police, cover or remove your shoes before leaving the area if you suspect contamination and do not touch anything unnecessarily.

4. Hold your breath when possible until leaving the immediate area of possible high airborne concentrations.

B. Other Hazards

1. Accidents involving both radioactive material and infectious agents.

   Deactivate the biohazard and notify Radiation Safety and a Biological Safety representative (785-3555), or during off hours, call Campus Police at 111 and await instructions.

2. Fires, explosions, etc., involving radioactive materials.

   All personnel in the area should immediately leave the area as an orderly group and go to an area where there is a non-life threatening condition and sound the nearest fire alarm. Once in a safe area, notify the Campus Police (Phone 111) immediately. Notify them of any injured personnel. Do not leave your safe area without first being monitored for radioactive contamination. Call Radiation Safety (785-3555). Prevent unauthorized persons from entering the hazard area.

C. FOR ALL EMERGENCIES USE THE FOLLOWING GUIDES

Keep calm, use common sense, protect people, do not spread contamination. Always assume you are contaminated until a survey shows otherwise; call Radiation Safety or Campus Police and await instructions.

Spill Control Procedure

STOP...what you are doing
- Do not panic
- Stay in the immediate area
- Collect your thoughts and keep calm

PRESUME...that you are contaminated
- Do not spread the contamination
- Do not make any unnecessary moves
- If feasible, check for skin contamination

INFORM...others in the immediate area of the spill
- Have someone contact Radiation Safety
- during normal working hours: 785-3555
- after hours: 111 (Campus Police)

LOCALIZE...the spilled material
- Estimate the extent of the spill
- Place absorbent material on the spill (wear gloves)

LABEL...the area as contaminated
- Restrict individuals from entering or leaving the area

IV. Post Accident Reporting

For certain types of accidents, Radiation Safety may be required to report to authorities outside Yale University. Radiation Safety will require the cooperation of the Principal Investigator and individual users in collecting data and in revising procedures to prevent a recurrence.

APPENDIX - XXI   URANIUM AND THORIUM INFORMATION

Uranium and thorium are naturally occurring radioactive materials which are sometimes used in research laboratories, for example in electron microscope labs or in the geology department. These compounds are exempt from many regulations due to the fact that they are naturally occurring. Uranium/thorium nitrate and acetate compounds are ordered as a chemical, without regard to the radioactive element. However, these radioisotopes do emit alpha, beta and gamma radiation and should be handled appropriately. If you have any questions pertaining to safe handling procedures for uranium and thorium, please call Radiation Safety (785-3550).

Information and Safe Handling Tips

Safety Procedures

- Always wear personal protective clothing (gloves, lab coat, safety goggles).
- Continuously monitor experiments with a survey meter equipped with a pancake probe.
- All work with radioactive material should be performed on absorbent material.
- Exercise care when handling uranium and thorium in powder form to prevent spills or airborne material.
- Wash hands after each use.
- Refer to MSDS for chemical hazards.

Emergency Response

- If powder spills - cover the area immediately with a moist paper towel(s).
- If liquid spills - Cover the area immediately with absorbent material.
- Leave area and immediately notify the Radiation Safety Section (785-3555).
- If personal contamination is detected, wash affected area with copious amounts of water, and notify the Radiation Safety Section (785-3555).

Waste Disposal

- Dry waste such as gloves, absorbent material, and/or kimwipes that are contaminated with these compounds should be collected in a dry radioactive waste container. Contact the Environmental Services Section at 785-3551 to obtain a dry waste container, and for the prompt removal of your radioactive waste containers.
- Liquid waste that cannot be absorbed and disposed of as dry waste should be collected in a liquid radioactive waste container. Contact the Environmental Services Section at 785-3551 to obtain a liquid waste container, and for the prompt removal of filled containers.

As part of many research protocols, liquid supernatant is aspirated off using the building vacuum system. When using this system, a double trap set-up (see figure 1) is required. The aspirator tip and associated tygon tubing is connected to trap #1, where the liquid waste is collected. Trap #1 is then connected to trap #2 via additional tubing. Trap #2 is only inline in case trap #1 overflows, thus preventing liquid from going directly into the vacuum system. If liquid accidentally flows into trap #2, aspiration should cease, and all liquid waste should be disposed of appropriately. Under certain conditions some radioactive compounds may become, or may already be volatile (i.e. - ^{35}S-methionine, ^{35}S-Translabel®, etc.). When using volatile compounds, a charcoal trap should be fitted inline between trap #2 and the building vacuum supply. It is important to minimize/eliminate radioactive materials from entering the building vacuum system. This will prevent personnel exposures and the spread of contamination when the building vacuum system is serviced.

Note: *Trap #1, which contains liquid radioactive waste, should contain a growth retardant, be placed in a secondary container, and be appropriately shielded when applicable. All components should also be properly labeled with "Caution Radioactive Materials" tape.*

Figure 1: Vacuum Trap Set-up