List of Attachments

Attachment 1

Duties and Responsibilities of the Radiation Protection Committee

The Radiation Protection Committee (RPC) is appointed by the MIT President's Office. The current membership is attached. Faculty members of the Committee are selected from those who are involved in working with radioactive materials. In order to minimize unnecessary delays for approval of authorization applications involving relatively small possession limits, the Committee delegates authority to the Radiation Protection Officer (RPO) to review and approve applications involving the following maximum quantities of radionuclides:

1. Possession limits for unsealed material to be handled in the applicant's facilities: 1000 times the quantities listed in Appendix C, 105 CMR 120.297.
2. Possession limits for unsealed material to be handled in the Central Radioisotope Facility (room 6-017) under RPO (or designee) supervision: 10,000 times the quantities listed in Appedix C, 105 CMR 120.297.
3. Possession limits for sealed sources: 10,000 times the quantities listed in Appendix C, 105 CMR 120.297.

Such delegation of authority to the RPO is limited to the temporary approval of those applications that, in his/her opinion, follow thorough review by the health physics staff of the Radiation Protection Program (RPP), including no unusual radiation protection problems. All such approvals are subject to ratification by the Committee at its next scheduled meeting.

For applications that exceed the above quantities, but in the opinion of the RPO involve no unusual radiation hazards (following thorough review by the RPP's staff), letter balloting of the RPC may be utilized between meetings. An affirmative vote from a majority of the voting membership is required to constitute a letter-ballot approval.

Following are the specific duties of the Radiation Protection Committee:

1. Meet as often as necessary to conduct business but not less than quarterly.
2. Conduct periodic reviews and audits of the Radiation Protection Program and devote sufficient time to reviewing records, reports from the RPO, results of regulatory inspections, and written safety procedures, and observe audits performed by the RPO and the RPP staff to ensure the adequacy of the Institute's management control systems. Examples of program reviews include, but are not limited to:

    a. Periodic (2-year intervals) renewals of protocol or user authorizations issued by the RPC.
    b. Review of annual audit findings (of RPC approved users and facilities) by the RPP staff.

3. Conduct radiation safety evaluations of proposed authorized supervisors and licensed material uses in accordance with attached procedures and criteria.
4. Establish procedures and criteria for training and testing each category of worker.
5. Establish methods for maintaining records of the committee's proceedings and radiation safety evaluations of proposed users and uses of radioactive materials.
6. Adopt radiation safety manuals as necessary to ensure proper program implementation and good health physics practices. There should be an ongoing review of the existing required procedures for radiation protection.
7. Maintain a list of current committee members.
8. Implement consequences as necessary for projects or individuals that consistently are non-compliant with the requirements of the MIT required procedures for radiation protection.

Committee on Radiation Protection 2007

The Committee on Radiation Protection is responsible for the establishment and continuing review of an adequate radiation protection program at the Institute and its off-campus sites. The committee is also responsible for the Institute's compliance with radiation protection regulations promulgated by state, federal, and local agencies.

Current Committee Membership

VOTING MEMBERS	DEPARTMENT	ROOM	TELEPHONE
	Biological Engineering	56-786	3-8017
	Nuclear Science and Eng.	NW14-2211	2-3383
	Civil & Environ Eng.	48-311	3-1637
	Biology	E17-543	3-3013
	WIBR	WI-667	8-5188
	Physics	26-447	8-5639
	Civil & Environ Eng.	48-417	3-7128
	Nuclear Engineering	NW14-2207	8-6999
	Plasma Fusion Center	NW21-203	3-8440
	Environmental Medical	56-235	3-9389
	Radiation Protection	N52-496	2-3477
	Sponsored Programs	E19-750	3-3856
	Lincoln Lab	LL-B-325	181-2383
	Comparative Medicine	16-825	3-9435
	WIBR	WI-529	8-5156
	Radiation Protection	N52-496	2-3477
EX-OFFICIO MEMBERS:			
	Radiation Protection	N52-496	2-3477
	Radiation Protection	N52-496	2-3477
	Radiation Protection	N52-496	2-3477
	Radiation Protection	N52-496	2-3477
	Radiation Protection	N52-496	2-3477
	Radiation Protection	N52-496	2-3477
	Reactor Radiation Prot.	NW12-108	3-4203
	Bates Radiation Prot.	Bates Linac	3-9272
GRADUATE STUDENT REPRESENTATIVE:			
	Physics	26-402E	8-5437

* Non- voting Member of the Committee

Attachment 2
Duties and Responsibilities of the Radiation Protection Officer

The Radiation Protection Program (RPP) is a subdivision of the MIT Environmental Health and Safety Office. The Radiation Protection Program is responsible for providing advisory and technical services necessary for the implementation of MIT's radiation protection programs for both ionizing radiation and non-ionizing radiation.

The Radiation Protection (RP) Officer is in charge of the Radiation Protection Program. He/she is responsible for implementing the Institute's radiation protection program and for implementing the policies, procedures, and decisions promulgated by the Radiation Protection Committee. A technical staff of Health Physicists and Health Physics technicians supports the RP Officer. The RP Officer may delegate such duties as he/she deems appropriate to the Associate or Assistant Radiation Protection Officers under his/her direction, most of who are either certified by the American Board of Health Physics or have earned at least a Master's Degree. The RP Officer has the authority to suspend any authorization he/she deems unacceptable in terms of radiation safety.

The following are duties and responsibilities of the RP Officer and his/her staff:

1. Maintain surveillance of overall activities involving radioactive material, including monitoring and surveys of all areas in which radioactive material is used.
2. Determine compliance with rules and regulations, license conditions, and the conditions of project approvals authorized by the Radiation Protection Committee.
3. Monitor and maintain absolute and other special filter systems associated with the use, storage or disposal of radioactive material.
4. Provide necessary information on all aspects of radiation protection to personnel at all levels of responsibility, pursuant to 105 CMR 120.750.
5. Oversee proper delivery, receipt, and conduct surveys of all shipments of radioactive materials arriving at the Institute, as well as the packaging and labeling of all radioactive materials leaving the Institute.
6. Distribute and process personnel radiation monitoring equipment, determine the need for and evaluate bioassays, monitor personnel radiation exposure and bioassay records for trends and high exposures, notify individuals and their supervisors of radiation exposures approaching maximum permissible amounts, and recommend appropriate remedial action.
7. Conduct training programs and otherwise instruct personnel in the proper procedures for the use of radioactive material prior to use, at periodic intervals (refresher training), and as required by changes in procedures, equipment, regulations, etc.
8. Supervise and coordinate the radioactive waste management program, including effluent monitoring and record keeping of waste storage and disposal.
9. Store radioactive materials not currently in use, including waste.
10. Perform leak tests on all sealed sources, and calibration of radiation survey instruments.
11. Maintain an inventory of all radioisotopes at the Institute, and monitor the quantity of radioisotopes in conjunction with the amounts authorized by license.
12. Immediately terminate any activity that is found to be a threat to public health, safety or property.
13. Supervise decontamination and recovery operations.
14. Maintain other records not specifically designated above. For example, records of receipts, transfers, and surveys as required by regulation and license conditions.
15. Hold periodic meetings with and provide reports to licensee management and the Radiation Protection Committee.
16. Assure that radioactive material in the possession of the licensee conforms to the material authorized by the license.
17. Assure that only individuals authorized by the license use the radioactive material.
18. Instruct personnel in the proper radiation protection practices.
19. Conduct radiation surveys where indicated and keep records of such surveys, including summaries of corrective measures recommended and/or instituted.

20. Assure that personnel monitoring devices are used where indicated, exchanged at required times, and that records are kept of the results of said monitoring.
21. Investigate each known or suspected case of excessive or abnormal exposure to determine the cause and take steps to prevent its recurrence.
22. Be immediately available to serve as a point of contact with the Agency and give assistance in case of emergency (e.g., damage, fire, theft, etc.).
23. Assure that the RPP is implemented and that reviews are performed in accordance with regulations.
24. Assure that the proper authorities (i.e., the Agency, local police, U.S. DOT, etc.) are notified promptly in case of accident, damage, theft or loss of radioactive materials.
25. Assure that the terms and conditions of the license (such as periodic leak tests) are met, and that the required records (such as personnel exposure, leak tests, accountability, etc.) are maintained and reviewed for compliance with Agency regulations and license conditions.
26. Apply restrictions on the amount of occupational radiation exposure that an individual may receive during the entire length of his/her association with MIT.
27. Apply conditions of approval that must be adhered to with each project's proposed use of radioactive materials.

The Radiation Protection Program, under the direction of the Institute Radiation Protection Officer of the Environmental Health and Safety Office, has the following responsibilities:

1. Implementing the Institute's radiation protection program.
2. Operating the Institute's Central Radioisotope Laboratory and Storage Facility.
3. Providing such services as may be required for radiation protection and compliance with governmental regulations. The services include the following:

    a. Registration and training of radiation workers.
    b. Training of ancillary personnel.
    c. Monitoring of internal and external personnel radiation exposure.
    d. Radioisotope laboratory inspections, audits, and radiation surveys.
    e. Radioactive waste collection, management, measurement, and disposal.
    f. Calibration and repair of radiation protection survey instruments.
    g. Approval of all purchases of radioactive materials.
    h. Environmental monitoring.
    i. Leak testing and physical inventory of sealed radioactive sources.
    j. Monitoring and laboratory delivery of incoming shipments of radioactive materials.
    k. Preparation and monitoring of outgoing shipments of radioactive materials.
    l. Supervision of radiation emergencies and special decontamination operations.
    m. Operation of an MIT vehicle for transportation of radioactive materials.
    n. Maintenance of radiation protection records.

4. In addition, the Radiation Protection Program (RPP) staff is available for:

    a. Consultation on laboratory design, shielding, and other radiation exposure control methods, and
    b. Presenting lectures and training exercises on radiation protection techniques.

Attachment 3

Supplement to Item 8. Training For Individuals Working In Or Frequenting Restricted Areas

Attached is a form titled "Radiation Worker Registration Form." Prior to any person's use of licensed radioactive materials at MIT, they will be interviewed by RPP staff for specific detail, attend a radiation safety lecture, and/or web based training, pass an exam (written or oral), and be assigned to an active Authorization under the supervision of a project supervisor. The interview, lecture and exam typically last three hours. Attached is the training outline for an authorized radiation worker, a description of our training program and an example of the radiation worker quiz. The passing grade is 70%. Any person scoring less than 70% will attend a one-on-one review session with a member of the RPP staff.

Radiation Safety Training Program Outline for Radiation Workers

Regulatory Climate
- Regulating Agencies, 105 CMR 120.200 and 105 CMR 120.750
- License, License Conditions, Inspections, Authorization Process
- Organizational Responsibility

Radiation Physics
- Definitions
- α, β, γ, and x Radiation
- Isotopic Information

Radiological Units and Quantities
- Radiation, Radioactivity, Exposure and Dose
- Radiation Dosimetry
- Radiation Maintenance/Surveys

Radiation Dose Limits
- Background Radiation
- Dose Limits, Reporting of Occupational Doses

Health Effects
- Somatic, Genetic, Teratogenic

Waste Management
- Segregation, waste minimization

ALARA
- Definition and Policy, External and Internal Dose Reduction
- Contamination Control and Radioactive Waste Reduction

Operational Topics
- Security of Radioactive Materials, Transportation, Closedown Surveys, Procurement of Licensed Material, Licensed Material Use/Inventory Logs, Equations and Rules of Thumb

Emergency Procedures
- Radiation Worker's Reporting Responsibilities and Emergency Procedures

Additional training on an individual, hands-on style, basis is provided for any individual wanting to use the Gammacell irradiators, perform an iodination or handle large activity sources. Personnel monitoring is typically discussed at the time of the interview. Section 10.1 has a more detailed discussion regarding personnel monitoring.

Retraining for all authorized radiation workers occurs on a biennial basis, which coincides with the Authorization renewal process. This is discussed in more detail elsewhere.

Training Program

Retraining of authorized radiation workers has evolved into a very successful schedule of retraining on a two-year basis in conjunction with the special training and renewal of each laboratory authorization. A special training session is scheduled in which the terms and conditions of that renewal authorization are thoroughly reviewed with all authorized radiation workers. This opportunity is also utilized to review all handling precautions and procedures relative to the general use of radioactive materials at MIT, audit results, regulation updates, and current events.

Authorized supervisors of projects involving radioactive materials are required by RPP policy to be members of the faculty or senior staff with sufficient rank to be authorized to enter into a contract that obligates the institution. In addition, the review process involves the determination of previous experience to justify authorization at the level of activity proposed. If necessary, the project can be conducted under the supervision of an established supervisor until the necessary training and experience is gained and proficiency is proven.

The authorized supervisor is responsible for assuring that those under his supervision attend the appropriate training in basic radiation protection techniques provided by the RPP staff before working with radioactive materials. The supervisor is then responsible for assuring that the specific training in laboratory techniques in the specific assignment are adequately provided and understood to allow for safe and efficient performance of the task at hand. As indicated above, this training is reinforced by RPP staff at least biannually and observed during regular laboratory audits.

The RPP is responsible for developing a comprehensive radiation safety training program such that all other users (e.g., technical radiation safety staff, nurses, waste handlers, animal caretakers, and ancillary staff) understand the radiation hazards associated with their work, and are able to take appropriate action to prevent unnecessary exposure.

Facilities (housekeeping and maintenance) and Campus Police (security) personnel are both given annual reviews of radiation hazards and appropriate precautions by the Radiation Protection Program, with initial training provided by their direct supervisor.

Clerical and other departmental personnel who work in the vicinity of radioactive materials are offered the opportunity to attend a lecture on radiation hazards and appropriate controls given by an RPP staff member.

MIT Radiation Safety Exam

Do not write on the test form itself or remove it from the classroom!

1. After 5 pm, you spill approximately 10 microcuries (uCi) of radioactive material. Your response is:
   a. Clean up the spill and call RPP to inform them of the spill the next day.
   b. Close and lock the door to the lab and inform your supervisor
   c. Check yourself for contamination then call 100 and follow the instructions of MIT Police
   d. Leave the lab, go home and take a warm shower to remove any contamination

2. The radiological unit rem is used to quantify:
   a. x-ray or γ photon radiation exposure in air
   b. radiation absorbed dose in any material
   c. the half-life of radioactive material
   d. the biological effect or dose equivalent of radiation

3. Which of the following is the occupational dose equivalent annual limit for the whole body:
   a. 1000 mrem
   b. 1250 mrem
   c. 5000 mrem
   d. 15000 mrem

4. What does the acronym "ALARA" stand for?
   a. at least a rem allowed
   b. as low as reasonably achievable
   c. as long as readily available
   d. as low as readily acceptable

5. What is the usual method to decontaminate your hands if they become contaminated with radioactive material?
   a. wipe with a soft cloth or towel
   b. rinse with hot water and potassium permanganate
   c. wash thoroughly with a mild soap and luke-warm water
   d. wait for the radiation to decay

6. The best method to detect removable tritium (^3H) contamination is:
   a. a Geiger-Mueller detector
   b. an air-ionization detector
   c. wipe tests followed by liquid scintillation counting
   d. air sample analysis

7. After working with radioactive material you must perform a close-down survey. A close-down survey entails:
   a. A radiation survey of your hands, feet, lab coat and street clothes
   b. A radiation survey of the work area and adjacent area, including the floor
   c. A radiation survey of any equipment used with radioactive materials
   d. All of the above

8. For low energy β emitters, like ^{35}S and ^{14}C, a survey meter equipped with a(n) _____ should be used to detect contamination.
   a. Condenser R-meter
   b. NaI scintillation probe
   c. Geiger-Mueller (G-M) pancake probe
   d. ZnS scintillation probe

9. The exposure rate measured at a distance of 10 cm from a gamma emitting radioactive point source is 10 mR/hr. The exposure rate at 30 cm should be.
   a. about 33.3 mR/hr
   b. about 11.1 mR/hr
   c. about 3.3 mR/hr
   d. about 1.1 mR/hr

10. Which of the following statement is true regarding MIT's policy on security of radioactive materials?
   a. All stock radioactive material must be secure at all times (including sealed sources).
   b. All registered radiation labs must be locked when vacant.
   c. All experiments involving radioactive materials must be labeled or posted
   d. All of the above

11. Which is the most effective shielding material for X or gamma radiation from ^{125}I?
   a. polyethylene
   b. paper
   c. lead
   d. aluminum

12. Whereas the purpose of 105 CMR 120.200 prescribes specific standards for protection against radiation, the purpose of 105 CMR 120.750 is to:
   a. provide information on decay and shielding requirements
   b. establish requirements for notices, instructions, and reports from employer to employee
   c. determine fines and penalties for not following the standards for protection against radiation
   d. detail the instructions for transportation of radioactive materials

13. The purpose of wearing a whole body radiation monitoring badge is to monitor for potential exposure from:
   a. alpha emitters like ^{222}Rn
   b. radioactive isotopes like ^{3}H
   c. low energy beta emitters like ^{35}S or ^{14}C
   d. radioactive isotopes such as ^{32}P or ^{125}I

14. A researcher receives 5 mCi of ^{14}C and 500 μCi of ^{32}P on Friday. The researcher goes on vacation and the radionuclides are not used until two weeks later. Approximately how much activity remains from the two samples, ^{14}C and ^{32}P respectively, at this time?
   a. 2.5 mCi and 250 μCi
   b. 5.0 mCi and 500 μCi
   c. 5.0 mCi and 250 μCi

d. 2.5 mCi and 500 μCi

15. Which of the following lists the ionizing radiations in the proper relative penetrating ability from lowest to highest?
    a. alpha-beta-gamma
    b. gamma-beta-alpha
    c. alpha-gamma-beta
    d. gamma-alpha-beta

16. Storage of food or beverages within an RPP registered cold room, freezer or refrigerator is prohibited because:
    a. radioactive materials must not be stored at very low temperatures
    b. this is a violation of MDPH license requirements
    c. the radiation may cause discoloration
    d. the food's flavor will change due to radiation exposure

17. The critical organ for ^{125}I is the:
    a. whole body
    b. skin of the whole body
    c. thyroid
    d. liver

18. Radioactive waste is segregated prior to disposal. Which of the following segregation criteria are correct?
    a. liquid separated from solids
    b. by half-life: >120 days, 20-120 days, < 20 day (^{32}P)
    c. sharps separated from solid waste
    d. all of the above

19. From the list below, select the dose limit for the full term of pregnancy for a declared pregnant woman.
    a. 1000 mrem
    b. 500 mrem
    c. 250 mrem
    d. 0 mrem

20. Generally speaking, which person would have the greatest risk from a given radiation exposure?
    a. a 60 year old female
    b. a 60 year old male
    c. a 30 year old male or female
    d. a fetus or embryo

Attachment 4
Facility Diagrams
Each facility diagram is followed by a "to scale" drawing of the building floor the facility is located on.

Radioactivity Analysis Lab (RPP):
N52-450

Hot Lab (RPP):
N52-446A

Waste Management:
16-025
16-039
NW13-141

Instrumentation Calibration:
16-029

Central Isotope Storage Facility:
6-017

Iodination Facilities:
E17-329
68-284
56-354A
N52-446A

Attachment 5: RPP Instrumentation

RPP Survey and Measurement Equipment Used in Routine and Decommissioning Surveys and Analysis

The following instrumentation belongs to the RPP group and is calibrated and maintained by RPP:

RPP Instrumentation

Type	**#**	**Detector Type**	**Calibration**	**Cal Frequency**
Survey instruments	30+	GM: pancake, end window, cylindrical	Dose rate; efficiency	Annual and after repair
Survey instruments	10+	NaI scintillation; thin crystal	Efficiency, thyroid monitoring	Annual
Ion chambers	3	Ion chamber	Dose rate	Annual
Floor monitor	1	Gas proportional 500 cm^2	Efficiency	Annual
Bench monitor	1	Gas proportional 100 cm^2	Efficiency	Annual
Liquid scintillation analyzers	3	Liquid scintillation	Efficiency	Daily; Biannual
Whole body counter	1	NaI	Efficiency/ nuclide identification	Weekly; Biannual
Thyroid counter	1	NaI	Efficiency	Weekly; Biannual
Micro Rem meters	2	Scintillation	Dose rate	Annual
Proportional	1	Gas flow	Alpha/beta efficiency	Weekly; Biannual
Gamma Counter	2	NaI	Efficiency	Monthly; Biannual
Environmental Gamma Spec.	1	Intrinsic germanium	Efficiency/ nuclide identification	Weekly; Biannual
Portable gamma Spec.	1	NaI	Efficiency/ nuclide identification	Biannual

Attachment 6 Survey Instrumentation Calibration

M.I.T. Radiation Protection Program

Standard Operating Procedures for the Instrument Calibration, Maintenance and Repair Program

1. Purpose
   1.1 This procedure outlines the responsibilities of the RPP technician assigned to the Instrument Calibration, Maintenance and Repair program. This document also outlines the specific steps involved in the calibration process.

2. Scope
   2.1 M.I.T. uses radionuclides and radiation producing machines in a wide variety of research efforts. In order to maintain exposures As Low As Reasonably Achievable (ALARA) laboratories are required to purchase portable survey equipment. This equipment needs to be initially calibrated, periodically checked for operation and occasionally repaired. In order to facilitate these needs the M.I.T. Radiation Protection Program has a centrally located calibration/repair facility with a N.I.S.T. traceable ^{137}Cs source and two portable radiation standards. This procedure deals with all operations of this facility and the associated paperwork.

3. Equipment
   3.1 JL Shepherd and Associates model 81 Beam Calibrator sn 7135 (3Ci ^{137}Cs source, 11/18/94 calibration date).
   3.2 __mCi 137Cs source
   3.3 WMB Johnson Pulser 3.4
   Ludlum Model 500 Pulser

4. Calibration Procedures
   4.1 Initial and Post-repair Calibrations
      4.1.1 All calibrations of this type are performed with the 3Ci ^{137}Cs N.I.S.T. traceable standard.
      4.1.2 Prior to calibration the instrument shall be pulsed using the WMB Johnson or Ludlum Model 500 pulser to determine if the electronics are operating properly.
      4.1.3 Check the high voltage to ensure that it is at the appropriate level for the particular detector utilized.
      4.1.4 Follow these steps for operation of the _Ci ^{137}Cs calibrator:
         4.1.4.1 Adjust the detector table height so that the center of the detector to be calibrated will be inline with the center of the radiation beam.
         4.1.4.2 Center the detector over the 0-0 mark on the detector table grid
         4.1.4.3 Position the instrument so that it may be read from the reflection in the mirror.
         4.1.4.4 Remove the locking pin from the calibration unit.
         4.1.4.5 Close the pressure relief valve on the air pump and turn the pump on. The line pressure at the calibrator input should be approximately 40psi, which can be read from the line pressure regulator.
         4.1.4.6 Flip the set-up switch on the operating tower to the on position.
         4.1.4.7 The door to the room is interlocked and must be closed for operation.
         4.1.4.8 Turn the power switch to the “ON” position, all interlock lights on the

control panel should be illuminated.

4.1.4.9 Turn the "SOURCE ARM" key to the "ON" position.

4.1.4.10 The irradiation time may be manual or preset. With the selector switch in the "MANUAL" position, the timer will show elapsed time. With the selector switch in the "PRESET" position, the timer will control exposure.

4.1.4.11 The instrument shall be calibrated at two points on each scale, one at 25% and the other at 75% of full-scale deflection.

4.1.4.12 Determine the appropriate distance and absorber combination from the chart in attachment A for the desired dose rate.

4.1.4.13 Press the "IRRADIATE" button, the alarm will sound for a preset time prior to source exposure. At the end of the alarm the source will be in the exposed position.

4.1.4.14 Observe the reading, if the measurement is within 10% of the actual dose rate proceed to the next desired calibration point. Otherwise lower the source, make any necessary adjustments and reirradiate.

4.1.4.15 After calibration is complete attach a calibration label to the instrument and update the calibration database.

4.1.5 NaI detectors are calibrated using a set of calibrated simulated ^{125}I standards.

4.1.5.1 Each scale is calibrated against a different strength ^{125}I source placed in a thyroid phantom.

4.1.5.2 The ^{125}I detection efficiency is determined at one centimeter from a source filter.

4.1.5.3 A calibration sticker is attached to the NaI detector.

4.2 Routine calibration checks and maintenance

4.2.1 Routine calibrations of instruments are performed in the field using or a _mCi ^{137}Cs source for GM detectors and the ^{125}I standards for the NaI detectors.

4.2.2 Routine calibrations are performed at annual intervals.

4.2.3 A calibration cart is used for transporting the sources around the institute and for locking them when visiting a laboratory.

4.2.4 The cart will be equipped with enough supplies to make any minor repairs necessary in the field.

4.2.5 The calibration of the NaI detectors is the same as previously mentioned.

4.2.6 The calibration of GM detectors is as follows:

4.2.6.1 A calibrated dose rate stick is placed on the cart and the source is placed at the end of the stick. The source is either shielded or unshielded depending on the desired dose rate.

4.2.6.2 Center the detector over the premarked dose rate point on the stick.

4.2.6.3 Measurements are made at 25% and 75% of full-scale deflection.

4.2.6.4 If the measured dose rate is within 10% of the actual proceed to the next calibration point. Otherwise make necessary adjustments and remeasure the dose rate.

4.2.7 If an instrument cannot be calibrated or repaired in the field it shall be brought back to RPP for repair.

4.2.7.1 Fill out a Maintenance and Calibration Work Order and give the white copy to the project as their receipt. The yellow and pink copies accompany the instrument.

4.2.8 Update the calibration record on the side of the instrument (attach a new one if necessary).

4.2.9 Update the instrument database.

5. Instrument Repair
   5.1 Instruments in need of repair shall be fixed within two weeks of delivery to the RPP. Those instruments that cannot be repaired within this time frame because of a lack of expertise shall be returned to the laboratory so they may be returned to the manufacturer or suitable repair facility.
   5.2 Instruments shall be inspected for potential problems such as corrosion, loose connections, etc. prior to return to service.
   5.3 An adequate supply of spare parts shall be kept in stock at all times to quicken turnaround time.
   5.4 All instruments shall be thoroughly cleaned prior to their return to service.

Sample calibration certificate

Assigned to:

Manufacturer: Ludlum Measurements Inc.
Model #: 3
Serial #: 30572
Detector Model #: 44-9
Detector Serial #: PR193423

Calibration Source:
Radionuclide: ^{137}Cs
Activity: ___Ci; JL Sheppard Type 6810 capsule
Calibration Date: 11/24/1994
Accuracy: +/- 5%
S.N.: MB-4419

Calibration: Dose rate

Range	Distance from source mm	Absorber	Exposure rate mr/hr	Instrument reading	Correction factor	Comments
X 1000						
X 100	1047	4	150	150	1	
	1813	4	50	50	1	
X 10	1197	40	15	15	1	
	2072	40	5	5	1	
X 1	1248	400	1.5	1.5	1	
	2162	400	0.5	0.5	1	
X 0.1	1047	8000	0.15	0.15	1	
	1282	8000	0.1	0.1	1	

Battery check: OK

Calibrated by: _____

Date Calibrated: 2/25/16 Recalibration Due: 5/2/2008

RP-01
Rev. 11/03

Authorization No._____
Expiration Date: _____

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

APPLICATION FOR AUTHORIZATION TO POSSESS AND USE RADIOACTIVE MATERIAL

INSTRUCTIONS: Complete Section I and forward to the Radiation Protection Office, Room N52-496. When approved, a copy of the application, with a designated Authorization number, will be returned to the Project Supervisor. To place a purchase order, submit to your purchasing agency a purchase requisition on which is stated "Radioactive Material" and the designated Authorization number.

SECTION I

1. Identification of persons (a) who will use and (b) who will supervise use of radioactive material:
   (a) Name of person(s) who will use the material: (List principal user first)

Name	**Department**	**M.I.T. Title**	**Room No.**	**Tel. No.**

   (b) Name of person who will supervise the use of the material:

Name	**Department**	**M.I.T. Title**	**Room No.**	**Tel. No.**

2. Rooms where the material will be handled:

   (a) Material stored in: _____

   (b) Material used in: _____

3. Description of material to be procured:

Radio nuclide	Amount of Activity		Chemical and physical form of material to be procured	Comments
	To Be Possessed*	In Use Per Experiment		

*Maximum amount to be possessed by project at any one time.

4. Is any of the radioactive material used as a label for potentially biohazardous material, toxic chemicals, or carcinogenic/mutagenic material? Yes ____ No ____. If answer is "yes," explain on a supplementary page.

5. To be procured from: M.I.T Reactor_____ Commercial Supplier_____ Other: ___

6. Type of investigation for which the material will be used: As Identified In Individual Project Authorizations

7. Principal procedures involved in the use of the material: Include procedures important to the consideration of contamination control, such as: evaporation, transfer of powder, etc.

Nu-clides	Activity mCi	Room Used	Exhaust Ventilation Used	Procedure Description

If item 7 is continued on a supplementary page, check here _____.

8. Radiation protection: Check special equipment that will be used to control external and internal radiation exposure. (If item 8 is continued on a supplementary page, check here _____.)

___ Glove-box
___ Transportation container
___ Scintillation-survey Meter
___Fume hood
___ Protective gloves
___G.M. Survey Meter
___Shielding
___Lab-coat
___Ion-chamber Survey Meter
___Handling tongs
___Shoe covers
___Dosimeter
___Shielded storage container
___Trays
Monitoring ___ Badges
Body ____
Wrist ____
Fingers ___
___Radiation signs and labels
___Mechanical pipette

9. Radioactive-waste disposal:

Type of Waste	Method of Disposal
Solid	Into RPP collection container in room #
Liquid	Into RPP collection container in room #
	Into sink of room #_____
Scintillation Fluid	Into RPP collection container in room #
Animal tissue	To be stored (for RPP collection) in freezer in room#
Special waste*	Describe on attached sheet (check#)

*Waste in form of gas, pyrophoric or pathogenic material are to be considered special wastes.

10. Name of person completing items 1 through 9_____

11. Project Supervisor's approval (Signature)_____Date _____

Project Supervisor's name (Please Print)_____

SECTION II (This section to be completed by the Radiation Protection Program.)

A. Comments relating to the application:

B. Following are the specific conditions of approval concerning work with radioactive materials under this authorization:

C. This application is approved with the following general conditions:

1. The proposed work with radioactive material shall be performed in the manner specified in Sections I and II-B, C, D. There shall be no changes in the approved procedures without the prior approval of the Radiation Protection Committee. The Radiation Protection Program shall be notified prior to a change in place of use or storage of radioactive material.

2. The use, storage and disposal of the radioactive material shall be in conformity with (a) the provisions of the Massachusetts Regulations for the Control of Radiation, 105 CMR 120.00 and (b) the provisions of "M.I.T Required Procedures for Radiation Protection."

D. In addition the following standard conditions of approval are emphasized:

- ❑ The project supervisor's responsibilities must be transferred to another person (with supervisory qualifications) during any extended leaves from the Institute (a month or longer). RPP approval of any such changes must be secured in advance.
- ❑ No transfer of powdered radioactive material is allowed under this -authorization. If powdered or crystalline material is purchased, it will be put into solution in the original shipping container.
- ❑ All procedures which may result in airborne contamination of radioactive materials will be performed in a hood which is approved for work with radioactive material.
- ❑ All unattended containers of radioactive material or any apparatus containing radioactive material must be labeled with properly completed "Caution Radioactive Material" sign or label.
- ❑ Radioactive material will be doubly contained in a shatterproof container when transported between laboratories and/or through corridors.
- ❑ There will be no mouth pipetting of radioactive solutions.
- ❑ Radioactive wastes will be disposed of in RPP approved radioactive waste containers and/or in RPP approved laboratory drains. A record of waste disposal will be kept by recording the experimenter's name, nuclide, amount, and date on the appropriate RPP forms.
- ❑ An appropriate functional survey instrument will be readily available for contamination control monitoring in all laboratories in which millicurie (mCi) quantities of ∃(emitters are being handled (purchase of 1 mCi or more of stock solution constitutes such handling.) An exception to the above will be for radioiodines that are not protein-bound. In such cases an appropriate functional survey instrument will be required if $\geq$ 100 :Ci is handled. Alpha emitters shall have the same 100 :Ci limit.
- ❑ The project will ensure that their radiation survey instruments are in proper working condition. If repairs or calibrations are required the project will deliver the instruments to the Radiation Protection Program. RPP will calibrate the instruments at six-month intervals.
- ❑ Liquid scintillation wastes and animal carcass wastes that are exempt from radioactive waste disposal regulations will be packaged in accordance with RPP regulations.
- ❑ Packages of radioactive material received by the project will be opened in accordance with RPP instructions that are attached to each package.

E. Signature of Reviewer_____ Date_____

Approved by: _____Date _____

For M.I.T Radiation Protection Committee

F. Termination of this authorization:

1. Work with radioactive material terminated (date)_____

2. Disposition of:
   Radioactive material_____
   Waste containers_____
   Survey meter(s)_____

3. Residual Contamination:
   Hood(s)_____
   Sink(s)_____
   Laboratory surfaces_____

4. Lab. area checked out by: _____ Date:_____

5. Approved for "terminated file"_____Date:_____

Attachment 8
External Exposures

Monitoring of an individual's external radiation exposure is required by 105 CMR 120.226 (A) if the external occupational dose is likely to exceed 10% of the annual dose limit appropriate for the individual. Evaluations of the individual's potential exposure levels are performed during the registration and training of radiation workers by the radiation protection office staff. Radiation workers are required to complete form RP-50 (see attached) which becomes part of their personnel records at the Radiation Protection Program (RPP) office. At the completion of the RPP training, an evaluation of dosimetry needs is performed based upon the following:

1. Information provided by the radiation worker, such as radionuclides, amounts, and intended uses.
2. The authorized radionuclides and their possession limits.
3. The history of exposure levels for the authorized group.

Upon completion of the evaluation by the RPP office staff, the type of monitoring required is determined and recorded in Section III of the RP-50. A reevaluation is performed if the authorization is amended to allow radionuclides or amounts that may affect the need for external monitoring.
Note: Currently 100% of the workers monitored are required by license condition, convenience badging to monitor all exposure levels, or monitoring is requested by the radiation worker. No current radiation workers are required to be monitored per 105 CMR 120.226 (A), thus no individual annual summaries are required.
All radiation workers who are required to be monitored per 105 CMR 120.226 are provided an annual summary of their exposure reports. All workers are provided bimonthly radiation dosimetry reports which include the annual exposure totals. These reports are sent to the project supervisor for the authorized project. In addition, all radiation workers required to be monitored per 105CMR 120.226 are requested to complete form RP-59 and obtain a radiation exposure history.

Internal Exposures

Monitoring of an individual's intake of radioactive material is required by 105 CMR 120.226 (B) if the intake is likely to exceed 0.1 ALI during the year.
Evaluation of the individual's potential internal exposure levels are performed during the registration and training of radiation workers by the RPP staff. Radiation workers are required to complete form RP-50 (see attached) which becomes part of their personnel record at the RPP office. At the completion of the RPP training, an evaluation of bioassay needs is performed based upon the following criteria:

1. Information provided by the radiation worker such as radionuclides, amounts, and intended uses thereof.
2. The authorized radionuclides and possession limits.
3. License and authorization conditions of approval regarding bioassay.

Upon completion of the evaluation by the RPP staff, the type of bioassay monitoring required is determined and recorded in Section III of the RP-50 form. A reevaluation is performed if the authorization is amended to allow radionuclides or amounts that may affect the need for external monitoring.
Note: Currently 100% of the workers monitored are required by license or authorization specific conditions of approval.

RP-50
Revised 10/03

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
ENVIRONMENT HEALTH AND SAFETY
RADIATION PROTECTION PROGRAM

RADIATION WORKER REGISTRATION FORM

SECTION I

Date _____

1. Name _____
(Print) Last First Middle Initial

2. Kerberos ID _____ MIT ID # _____
(MIT email)

3. Date of Birth _____

4. Job Title_____

5. Office or Lab Room # _____ Phone # _____

6. Department _____

7. Supervisor/PI (of Radioactive Materials Authorization) _____

8. Brief description of proposed work with radiation:

9. Principal radioactive material to be used in your proposed work:

RADIONUCLIDE(S)	TOTAL ACTIVITY ORDERED (mCi)	CHEMICAL OR PHYSICAL FORM ORDERED	MAXIMUM AMOUNT USED PER EXPERIMENT

10. Radiation producing equipment, such as analytical x-ray or accelerator, to be used in your present work:

Type _____ Maximum energy _____

FOR OFFICE USE ONLY

AUTHORIZATION #: _____ BADGE NUMBER: _____

SUPERVISOR: _____ SERIES CODE: _____

RPP STAFF: _____ TERMINATION DATE: _____

LAST NAME: _____

SECTION II PREVIOUS EXPERIENCE WITH RADIATION

Have you had previous experience working with radioactive material or other ionizing radiation sources?
☐ Yes ☐ No

If yes, have you received greater than 100 millirem in this calendar year from occupational exposures to radiation?
☐ Yes ☐ No

1. Previous experience with radioactive materials:

RADIONUCLIDE(S)						
GREATEST ACTIVITY USED						
EMPLOYER(S) NAME & ADDRESS (Note: This information is required for workers monitored for occupational radiation dose during the current year.)					**DATES FROM**	**TO**
* List most recent first *						

2. Previous experience with radiation producing equipment (x-ray, accelerator, reactor):

TYPE(S) OF EQUIPMENT	**EMPLOYER(S) NAME & ADDRESS**	**DATES FROM**	**TO**

I have received and read the *Required Procedures for Radiation Protection*. I have attended the RPO radiation safety course and was afforded the opportunity to ask questions addressing any concerns I have relating to potential occupational radiation exposures.

I agree to comply with 1) all applicable rules and regulations governing the safe use of radioactive materials and 2) the conditions of approval listed on my project authorization, approved by the MIT Radiation Protection Committee.

_____ _____

Signature Date

SECTION III TO BE COMPLETED BY THE RADIATION PROTECTION OFFICE

Interviewed by: _____ Date _____

Type of Interview: ☐ Radioisotope ☐ X-Ray ☐ Reactor ☐ Accelerator ☐ Fusion

Instruction Material(s) Supplied: ☐ RPP Required Procedures ☐ Reactor RPP Manual

☐ Other _____.

Authorization No.: _____ Supervisor: _____

_____ _____

_____ _____

_____ _____

Date Terminated: _____ Date Reactivated: _____

_____ _____

_____ _____

_____ _____

External Radiation Monitoring:

☐ Required by 105 CMR 120.226
☐ Required by License Conditions
☐ Requested by user/convenience badging
☐ None Required or Requested

☐ Body ☐ Wrist ☐ Finger

Internal Radiation Monitoring:

☐ Required by 105 CMR 120.226
☐ Required by License Conditions
☐ Requested by user/convenience monitoring
☐ None Required or Requested

☐ Urinalysis: Radionuclides _____
☐ Whole Body ☐ Thyroid

Reference # _____ Spare Badge # _____ Issue Date _____ Termination Date

Reference # _____ Spare Badge # _____ Issue Date _____ Termination Date

Reference # _____ Spare Badge # _____ Issue Date _____ Termination Date

☐ Summary of annual dose report required per 105 CMR 120.754

☐ Prior dose history required by 105 CMR 120.215 {Fill out Form RP-59}

Prior dose history request sent by: _____
(Name) (Date)

RADIATION SAFETY INSTRUCTION QUIZ

Use this form to record your answers by marking the box next to the selected answer.

DO NOT MARK THE QUIZ !!

1.	a.	b.	c.	d.
2.	a.	b.	c.	d.
3.	a.	b.	c.	d.
4.	a.	b.	c.	d.
5.	a.	b.	c.	d.
6.	a.	b.	c.	d.
7.	a.	b.	c.	d.
8.	a.	b.	c.	d.
9.	a.	b.	c.	d.
10.	a.	b.	c.	d.
11.	a.	b.	c.	d.
12.	a.	b.	c.	d.
13.	a.	b.	c.	d.
14.	a.	b.	c.	d.
15.	a.	b.	c.	d.
16.	a.	b.	c.	d.
17.	a.	b.	c.	d.
18.	a.	b.	c.	d.
19.	a.	b.	c.	d.
20.	a.	b.	c.	d.

Attachment 9 Bioassay Program
MIT Bioassay Guidelines

For normal operations the bioassay submission guidelines for radionuclides are as follows:

Unsealed alpha, beta, and/or gamma emitters other than unbound radioiodine and tritium: People working with more than 10 times the Annual Limit on Intake at any one time, appropriate bioassay is required within 10 working days for infrequent users and monthly for those performing procedures routinely. Typically, urinalysis for alpha or beta emitters, and in vivo measurements for gamma emitters.

Unbound radioiodine: Thyroid burden measurements are scheduled monthly for persons routinely handling 0.5 - 20 mCi of ^{125}I and/or ^{131}I and within 10 working days for handling more than 20 mCi. For occasional users (less than one iodination per month) handling more than 0.5 mCi, thyroid measurements are performed within 10 working days.

Tritium: individuals who use more than 10 mCi of ^{3}H in a non-contained form, other than metallic foil, are scheduled for urinalysis within: ten working days following a single operation, one month intervals for continuous operations, one week intervals for handling more than 100 mCi routinely, and daily for handling one curie or more routinely.

Unusual situations, such as with skin contamination, spill of volatile material, or any other unusual situation RPP may determine that bioassay is necessary. Also, under certain circumstances the above limits may prove to be overly restrictive, such as when a glove box is used. For this reason the MIT RPP can redesign the bioassay guidelines for a particular use of radioactive materials. As always the goal is to maintain doses ALARA. With this in mind any use of radioactive materials which could pose a dose in excess of 10% of the annual dose limits.

The review process for redesigning the bioassay guidelines for a particular use includes elements such as, protective equipment (i.e. hood, glove box), volatility, handling procedures (i.e. evaporations, heating, off gassing, aerosol), material composition (liquid, powder), radiation worker experience, and prior dose or bioassay information from the particular use if available.

Selected isotopes and the lowest annual limit on intake by ingestion and bioassay requirements without RPP special review.

Isotope	Lowest ALI 120 CMR App. B Table 1, Col. 1 mCi	Bioassay Limit mCi	Isotope	Lowest ALI 120 CMR App. B Table 1, Col. 1 mCi	Bioassay Limit mCi
^{3}H	80	10	^{51}Cr	40	400
^{14}C	2	20	^{55}Fe	9	90
^{32}P	0.6	10	^{59}Fe	0.8	8
^{33}P	6	60	^{86}Rb	0.5	5
^{35}S	6	60	^{99}Tc	4	40
^{36}Cl	2	20	^{125}I	0.04	0.5
^{45}Ca	2	20	^{165}Dy	1	10

Note that the use of volatile ^{125}I requires the use of an approved fume hood and a protection factor is accounted for in the bioassay limit listed above.

Attachment 10. Survey Technician Receiving and Delivering Radioactive Packages Guide

MIT Environment, Health and Safety Office
Radiation Protection Program

Package Check-in and Delivery
Procedure

I. Introduction

A. This document describes requirements for all radioactive material receipt and delivery for the Massachusetts Institute of Technology, Cambridge campus.

B. Packages containing radioactive material are received Monday through Friday from 8 a.m. to 5 p.m. at the following location only:
MIT Building E19 Receiving
Room E19-105
400 Main St.
Cambridge MA 02139

C. Special delivery requests must be arranged with the Radiation Protection Program.

II. General Package Receipt and Delivery Practices

A. Receiving personnel will notify the Radiation Protection Program upon receipt of radioactive shipments.

B. Packages are checked in by an RPP Technician, monitored for radiation levels, wipe tested for surface contamination, inspected for damage, and delivered if acceptable. State regulations require that packages be monitored and inspected within three hours of receipt if received during normal work hours.

C. Only those packages, which meet radiation monitoring and wipe test requirements, will be delivered to the appropriate end-user.

D. The RPP Technician will report any discrepancies in labeling, packaging, radiation monitoring and/or contamination levels to the RPP staff member responsible for packages for immediate attention. Should this staff member be unavailable, contact the staff member for the recipient's laboratory.

E. Any time that radioactive material is not delivered to the user, it must be determined if special handling like cold storage is required for material integrity and make arrangements for such.

F. All records must be complete. Use of "ditto" marks, arrows, or other notations in lieu of actual data is unacceptable. If data is not applicable or not available, use the abbreviation "NA."

III. Relevant Transportation Regulations

A. Package Labeling

1.	No Label	Excepted Quantity for activity ≤0.5 mrad/hr @ surface
2.	White I Label	<0.5 mrad/hr @ surface Background @ 1 meter
3.	Yellow II Label	>0.5-50 mrad/hr @ surface ≤1.0 mrad/hr @ 1 meter
4.	Yellow III Label	>50-200 mrad/hr @ surface >1-10 mrad/hr @ 1 meter

B. Excepted quantities of radioactive material are defined by the Department of Transportation Hazardous Materials Regulations of 49 CFR 100-177 and 178-179. They are formally called limited quantities.
   1. Limited quantities are excepted from some packaging and labeling requirements.
   2. A limited quantity equals 10^{-4} times the activity level for a particular nuclide in Table A-2 in 10 CFR 71 if it is a liquid, and 10^{-3} times the 10 CFR 71 activity level in Table A-2 for a solid.
   3. The limited quantities for selected isotopes are available where radioactive materials are checked-in.

C. The transport index (TI) is the dose rate at 1 meter rounded up to the first decimal place. The TI is indicated on Yellow II and Yellow III package labels.

IV. Responsibilities

A. RPP Secretary or RPP Technician
   1. Print from the RPP orders database the form titled *RP-08: MIT Radioactive Material Orders to be Received*. This is located under Reports, MIT reports, MIT Receiving in the database program. This is a list of all radioactive orders placed which have not yet been received at MIT.
   2. Give form *RP-08* to the check-in and delivery technician.
   3. Upon return of form *RP-08* from the technician, enter completed information, i.e. date of receipt, activity received, in the RPP database.

B. RPP Technician
   1. Using the *RP-08* form:
      a. Check the isotope and activity of radioactive material received against the information contained under "Nuclide" and "Amount" columns of *RP-08* form. The isotope and activity are recorded on the package's shipping papers.
      b. If information regarding "Nuclide" and/or "Amount" differ, contact an RPP staff member to determine appropriate response.
      c. Note that isotopes with short half-lives like ^{32}P may be received with activities greater than those ordered. This is a practice of the isotope suppliers to account for decay.
         (1) A short half-life is defined as less than 90 days for this function.
         (2) A 10-20% greater activity for short half-life materials is generally acceptable and for ^{32}P 40 - 60% is generally acceptable.
         (3) When the activity received exceeds 200% of ordered value for short half-life materials or 150% for long half-life materials, contact an RPP staff member for instructions.
   2. Perform radiation monitoring and wipe tests for each package in accordance with Appendix 2.
   3. Record the radiation monitoring and wipe test results on form *RP-012: Record of Checking-In and Delivery of Radioactive Material*.
   4. Keep and maintain *RP-012* forms in the logbook in room E19-105, the Shipping and Receiving Room.
   5. Attach form *RP-017: Procedure for Opening Packages Containing Radioactive Material* (orange label) to each package prior to delivery.
   6. Deliver packages which meet radiation monitoring and wipe test requirements only to the designated end-user or to a co-worker.
      a. The co-worker must be a registered radiation worker.

b. Packages are not to be left with a secretary, unless authorized by an RPP staff member.
c. The package must be secured from unauthorized use upon delivery.

7. Delivery documentation: obtain the signature and printed name of the package recipient on form *RP-08.*
8. Return completed *RP-08* form to the RPP Secretary.
9. It is the responsibility of the RPP check-in and delivery technician to maintain all applicable forms.

C. End-User / Recipient

1. Only those individuals who are registered by the Radiation Protection Program are authorized to work with radioactive materials.
2. End-users are instructed to:
   a. Monitor the inside of each radioactive shipping package for possible contamination.
   b. Deface or remove all radioactive labeling prior to disposal of the package or packing materials.

Appendix 1

Forms used during package check-in and delivery

Form RP-08
Form RP-012
Form RP-017
Form RP-318

RP-08

Rev. 5/03

Name:_____

MIT Radioactive Material Orders to be Received

Wednesday, May 12, 2004

PO Number	*Ordered by*	*Room #*	*Auth #*	*Nuclide*	*Amount mCi / GBq*		*Amount Recvd*	*Approved*	*Date Received*	*Signature*
030S003399	DOE, JOHN	E17-242	CCR-P	P-32	0.5	0.0185	_____	5/11/2004	_____	_____
10486463	HAND, JEFFREY	E18-422	9-G	I-125	0.006	0.000222	_____	4/29/2004	_____	_____
10490063	SMITH, SEAN	68-683	7-DA	P-32	5.0	0.0185	_____	5/11/2004	_____	_____

Instructions:

1. Complete columns "Date Received" and "Amount Received" for all of the day's reciepts

2. Report any discrepencies, i.e. wrong isotope, to an RPO staff member prior to delivery to the lab.

3. Return the completed form to the RPO secretary by 4 pm everyday.

Check-In Record of Radioactive Material

P.O. #	ORDERED BY	LAB NO.	NUC LIDE	mCi	Surface* mR/h	1 Meter* mR/h	LABEL	WIPE TESTS* dpm/ 100cm^2	Pack-age accepta ble**	Chkd within 3 hours ***	INIT.	DATE	COMMENT ****
									☐	☐			
									☐	☐			
									☐	☐			
									☐	☐			
									☐	☐			
									☐	☐			
									☐	☐			
									☐	☐			
									☐	☐			
									☐	☐			
									☐	☐			
									☐	☐			

* Notify the appropriate staff member if: (a) wipe test results exceed 2000 dpm/100 cm^2, (b) external radiation levels exceed 50 mrem/hr, or radiation levels at 1 meter exceed 1 mrem/hr. Wipe test MDA = 1000 dpm/100 cm^2. Typical detector efficiency is 10%.

** Package Acceptable for delivery indicates that the package is in good physical condition (i.e. not crushed, wet or damaged), meets with DOT requirements and isotope and activity are acceptable for delivery to the lab.

*** Package must be check in by RPP within three hours of MIT's receipt.

**** Note any discrepancies in labeling, packaging, or radiation and contamination levels.

M.I.T. RADIATION PROTECTION OFFICE

PROCEDURES FOR OPENING PACKAGES CONTAINING RADIOACTIVE MATERIAL

1. OPEN ONLY IN A REGISTERED RADIATION LAB

2. ASSUME INSIDE MATERIALS ARE CONTAMINATED UNTIL PROVEN FREE OF CONTAMINATION WITH A SURVEY METER AND/OR WIPE TESTING

3. NOTIFY RPP IF:

   a) CONTAMINATION OR LEAKAGE IS DETECTED.
   b) UNEXPECTED DOSE RATES ARE MEASURED.
   c) THERE IS A DISCREPANCY BETWEEN MATERIAL RECEIVED AND ORDERED.

4. REMOVE OR DEFACE "CAUTION - RADIOACTIVE MATERIAL" STATEMENT AND RADIATION WARNING SYMBOL FROM PACKAGES BEFORE DISPOSAL.

RP-318
Rev 11/96

SEALED SOURCE DELIVERY LOG

DATE	ORDERED BY	NUCLIDE	ACTIVITY	AUTHORIZATION	ROOM #	WIPE-TEST RESULTS	COMMENTS

Appendix 2

Procedure for Radiation Monitoring and Wipe Testing

Package Monitoring

General Requirements

Packages are to be monitored with a calibrated Geiger-Mueller (GM) detector on contact with each surface as well as at a distance of one meter. The one meter dose rate verifies the transport index (TI). The GM detector measurements on the package surface are to be taken through the side wall of the detector, not the detector window to conform with detector calibration geometry.

Package Labeling Requirements

No Label	Excepted Quantity for activity $\leq$ 0.5 mrad/hour @ surface
White I Label	$\leq$ 0.5 mrad/hour @ surface Background Dose Rate @ 1 meter
Yellow II Label	> 5 - 50 mrad/hour @ surface $\leq$ 1.0 mrad/hour @ 1 meter
Yellow III Label	> 50 - 200 mrad/hour @ surface 1 - 10 mrad/hour @ 1 meter

The receipt of sealed sources requires additional action as described in Section III below.

Radiation levels

Survey the entire package exterior for the highest dose rate and record it on *RP-012*. If no package dose rate above background is detected, record it as "< 0.05 mR/hr". Where the highest dose rate was measured on the package, take a dose rate 1 meter away and record that on *RP-012*. If the 1 meter dose rate is at background, record it as "< 0.05 mR/hr". Compare the dose rates at the package surface and at 1 meter to the package labeling requirements in Part I.A.2. above. If there are discrepancies, proceed to section II below.

Wipe tests

Perform wipe tests on all packages using standard two inch wipes looking for evidence of removable radioactive contamination. Measure the wipe for activity. Survey all wipes with the GM detector holding the wipe approximately 1 cm away from the detector. Wipe tests for packages containing $\geq$ 2 mCi ^{3}H or $\geq$ 7 mCi of ^{125}I should be sent to the Counting Room as soon as possible for liquid scintillation counting. Record the surface contamination levels. Since between 100 and 300 cm^2 may be wiped and survey results are reported in dpm/100 cm^2, correct the results for the area wiped. If no activity above background is measured, record the results as "< MDA". The limit for removable contamination is 22 dpm/cm^2 (10^{-5} µCi/cm^2). The activity on the wipe divided by the cm^2 of surface area wiped yields the surface contamination value. For example, if a wipe of 300 cm^2 surface area is counted and found to have 1000 dpm, the calculated contamination value equals about 4 dpm/cm^2.

Documentation

From the material packing list or shipping papers, record "PO #", "END-USER/LAB #", "NUCLIDE", and "ACTIVITY" on *RP-012*. Record the "SURFACE" and "1 METER" dose

rates under the "EXPOSURE RATE" column on *RP-012*. Record the dpm/100 cm^2 for "WIPE TESTS". Enter the initials of the person checking the package in under "CHECKED BY", and add the "DATE" of this evolution. The "COMMENTS" section is for discrepancies in labeling, packaging, or radiation and contamination levels.

Sealed Source Receipts

Sealed sources are received in the same fashion as other radioactive materials. In addition, sealed source packages are opened by RPP and wipe tested for leakage. Receipt and leakage testing for sealed source receipt is documented on form RP-318. The completed RP-318 form is turned into the RPP staff member responsible for sealed sources.

Package Discrepancies

In the event wipe test results show above background radioactivity levels (>MDA):

Place the package in a plastic bag. Place the covered package in the calibration room. Immediately notify the RPP staff member responsible for packages for proper follow-up. If the package is packed in dry ice to maintain material temperature requirements, place it in the RPP walk-in freezer.

In the event of excessive radiation levels:

Place the package in the calibration room. Appropriately shield the package. Immediately notify the RPP staff member responsible for packages.

In the event a package requiring radioactive material labeling is not properly labeled, immediately notify the RPP staff member responsible for packages.

In the event a package appears damaged upon receipt:

See if the delivery vehicle is still at Receiving and, if so, hold it for surveillance. Isolate the package from other materials and personnel. Contact the RPP staff member responsible for packages for further response.

Procedure for handling deliveries of sealed sources:

The technician checking-in packages will determine if a given shipment contains sealed sources. In general, sealed sources will be different radionuclides than the usual unsealed sources. In case of doubt, contact a staff member. All package check-in requirements for radioactive material receipts must be met for sealed sources as well.

In addition:

Open the package and obtain a wipe from the nearest accessible surface---not the active surface---of the source. Have the counting room technician count the wipe for alpha and/or beta-gamma radioactivity. The counting room technician will provide the wipe test results for form RP-318. Fill out form RP-318 for each source received. For each day that one or more sealed sources are received, a separate form RP-318 is required. Deliver the completed form RP-318 to RPP Staff. Deliver the package to the person that ordered the sealed source in the same manner as other radioactive material packages.

Attachment 11: Booklet Titled "Required Procedures for Radiation Protection"

This booklet is attached at the end of the license renewal application. The booklet is given to all new radiation workers during initial radiation safety training.

Attachment 12 Radiation Survey Technician Training Guide

MIT Radiation Protection Program

Training Guidelines

Routine Radiological Surveys

The purpose of this training module is to ensure that individuals performing routine radiological surveys at MIT perform them appropriately to aid efforts in maintaining occupational and public health and to meet regulatory requirements.

The structure of this training module is:

1. A discussion of the reasons for performing surveys, and the appropriate methods for radiological surveillance.

2. A demonstration by the instructor of appropriate techniques.

3. Demonstration of the appropriate techniques by the student.

Discussion

Radiological surveys help the RPP verify that radioactive materials are adequately controlled to maintain worker and public exposure ALARA. The public is anyone who is not a radiation worker including MIT maintenance, custodial and administrative staff, as well as visitors and other non-MIT persons. This objective may be partially met by taking radiological measurements and inspecting laboratories for adequate radiological safety practices.

105 CMR 120.225 states:

(A) Each licensee or registrant shall make, or cause to be made, surveys that:
- (1) are necessary for the licensee or registrant to comply with 105 CMR 120.200;
- (2) are necessary under the circumstances to evaluate:
  - (a) radiation levels;
  - (b) concentrations or quantities of radioactive material; and,
  - (c) the potential radiological hazards that could be present.

In addition, MIT=s Broad Scope Materials License requires laboratory radiation and contamination surveys, a review of radiation safety records and procedures, and radioactive material inventory checks. To facilitate the completeness of these reviews, the survey work sheet, called an RP-315, is attached.

Routine radiological surveys are performed monthly in low level laboratories and weekly in medium level laboratories. The designation low or medium is made by the RPP Staff for their individual projects based upon the isotopes used, the activity levels used, and other criteria that correlate with the relative level of hazards in the laboratory. These surveys are assigned to RPP technicians typically grouped by buildings or campus areas.

Required Elements

The steps in a routine survey include:

1. Obtaining the necessary equipment, supplies and paper work.
2. Entering the laboratory for inspection.
3. Observing radiological safety work practices employed by workers.
4. Inspecting laboratory equipment for proper safety elements.
5. Checking radioactive waste records.
6. Verifying the adequacy of radioactive material storage security and inventory records.
7. Verifying proper operability of the laboratory=s survey instruments.
8. Measuring radiation and contamination levels in radioactive material work areas.
9. Obtaining wipe tests from radioactive material work areas.
10. Taking immediate corrective actions in laboratory for deficiencies found in survey.
11. Documenting survey and inspection findings.
12. Preparing and counting wipe tests.
13. Filing completed survey records in RPP files.
14. Reporting survey findings to cognizant RPP staff.
15. Taking other corrective actions as appropriate for deficiencies not corrected in laboratory.

The following text describes the appropriate elements to complete these steps.

1. Obtaining the necessary equipment, supplies and paper work.

The necessary equipment, supplies and paper work include:

* a survey meter equipped with a Geiger-Mueller (GM) detector and a sodium iodide (NaI) scintillation detector;
* wipe test filter papers, one inch diameter typically;
* wipe test sample data envelopes;
* laboratory coat and safety glasses (Laboratory gloves are recommended);
* clipboard for paper work, if desired;
* Work Sheet for Radiation Surveys forms, as needed;
* pen; and
* pager so technician may be contacted while away from office.

2. Entering the laboratory for inspection.

When you reach the laboratory, the doors may be locked. You can perform other laboratory surveys and return later, or obtain a key or other means of access.

If, on the other hand, you reach the laboratory and the doors are not locked and there is also no one present, a security problem may be indicated. When you enter the laboratory and the door is

open and no one is present for an extended period of time, no radioactive materials should be available for removal. See section 6 below for more on security.

We also expect that radiation workers challenge persons who enter the laboratory to verify they have authorization to enter a radiologically controlled area. This challenge may be a simple nod from a person in the laboratory who knows you well to a request for proper MIT identification from a laboratory worker who does not recognize you. You should not be able to enter a laboratory without some acknowledgment or more aggressive challenge.

3. Observing radiological safety work practices employed by workers.

The survey technician is perhaps the most important element in our efforts to ensure radiological safety. When you inspect a laboratory for proper radiological safety, you will look to see that:

* there is no evidence of hand-to-mouth activities;
* persons working with radioactive materials are wearing the appropriate dosimetry, lab coat, gloves, etc.;
* radioactive waste reduction efforts are employed, as appropriate;
* laboratory survey meters are in use when radioactive material work is in progress;
* radioactive materials above Appendix C quantities are properly labeled with the trifoil, the words "Caution Radioactive Material," radionuclide, activity, and date;
* potentially contaminated items and radioactive materials below Appendix C quantities are identified as such;
* radioactive material labels on items in the regular trash, e.g., old shipping cartons or stock vials, have had their references to radioactivity removed or obliterated; and
* "Experiment in Progress" signs in use where radioactive materials are in use and the laboratory is unoccupied.

4. Inspecting laboratory equipment for proper safety elements.

Look for the following:

* appropriate waste collection containers in use;
* potentially contaminated equipment is properly labeled;
* apparent spills or other indications of a radiological hazard;
* general neatness and good housekeeping of radioactive materials work areas;
* that there is no indications of contaminated material in the regular waste containers, e.g., radioactive material labeling; and
* evidence of food or drink consumption.

5. Checking radioactive waste records.

There are five general types of waste disposal in the radiation laboratories - floor cans for dry solids, floor drums for liquid scintillation vials, bench-top one gallon plastic jars for high concentration liquids, bench-top one gallon plastic jars for sharps, and RPP registered sinks. Occasionally, you may also find five gallon pails used for the disposal of gamma tubes. Each must have some record for waste disposal. The floor cans, floor drums and bench-top jars all have 3" X 5" index cards on the lid, and the sinks are provided 81/2" X 11" record sheets in plastic holders near the sink.

There may be several of the cans, drums and jars because of the different half-lives of wastes for disposal. Inspect all the waste disposal records for 1) completeness, that is, name, radionuclide, activity, and date; and 2) that the correct radionuclide has been disposed of in the correct container. Sink cards must also be examined for completeness and accuracy. Radiation workers should be asked if there have indeed been no disposal where records are left blank. This is especially relevant if cans, drums or jars are partially filled, or if radiation is detected at a sink drain. Emphasize the importance of maintaining accurate inventory records for project purchase requirements and MIT=s requirement to have good inventory records as a whole.

6. Verifying the adequacy of radioactive material storage security and inventory records.

120.235: Security and Control of Licensed or Registered Sources of Radiation, states:

> (A) The licensee shall secure licensed radioactive material from unauthorized removal or access.
>
> (B) The licensee shall maintain constant surveillance, and use devices or administrative procedures to prevent unauthorized use of licensed radioactive material that is in an unrestricted area and that is not in storage.

MIT satisfies these requirements of the law by requiring that licensed materials that are not in use be locked up, and that licensed materials in use be provided constant supervision by the user or secured from removal by locks. Therefore, when you enter the laboratory and the door is open and no one is present for an extended period of time, no radioactive materials for experimental use should be available for removal.

You must verify that the radioactive material storage container, which may be a freezer, refrigerator, or lock box, is actually locked when you inspect the laboratory. The only times these radioactive material storage containers may be unlocked is when a worker is actually accessing the radioactive materials for use or when there are no licensed materials in the locking container. An unlocked container must be locked to reinstate compliance with the security regulations, documented on the survey form, and reported to the staff member responsible for that project.

When workers use radioactive materials in longer running experimental techniques they may provide security for the radioactive materials in use by posting “Experiment in Progress” signs. Operations such as incubation, hybridization, shaking, stirring, cooling or warming, may take

hours. It may not always be possible to lock the room where these long-term processes are employed. The researcher may alternatively use the "Experiment in Progress" sign to identify the hazard and prevent unauthorized or otherwise undesired disturbances. These signs must be completely filled out with the radionuclide, activity level, date, and responsible person's name.

Another required element of our security policy is maintenance of a complete and accurate inventory record of radionuclides by the projects. You must verify that these records appear up-to-date. It is not necessary that you verify the accuracy of the inventory, but you must look to see that it is being used effectively. These inventory records must also be convenient to the locking stock/stored materials location.

7. Verifying proper operability of the laboratory's survey instruments.

Though a designated individual from RPP calibrates survey instruments at least annually (most are calibrated semi-annually), the continued operability of survey instruments may be compromised by wear and tear. The survey technician must check the following items during his rounds:

* Are the batteries supplying adequate voltage as indicated by a battery check?

* Are there interferences on the detector? Some laboratory personnel cover the ends of detectors with plastic film to prevent contamination. This film, or other interference must not be allowed because it decreases the instrument's ability to detect low amounts of activity and low energy beta emitting radionuclides. When a worker surveys himself and his work area, he is attempting to find activity levels 100 cpm above background (roughly equivalent to 1000 dpm). Plastic wrap may shield this low level of activity. When a worker attempts to measure low energy beta emitters like ^{14}C, ^{35}S or ^{33}P, small activities like 1000 dpm may be shielded by plastic wrap. Workers may cover the detectors in plastic wrap where they are exclusively using millicurie levels of ^{32}P.

* Does the instrument respond to its source check source attached to the side of the instrument case? Not only can you check the response in this way, but you may also verify that the audible response works.

* Verify that the date of your instrument check falls between the calibration date and the recalibration due date. If the instrument requires calibration, note the instrument serial number and its location, then inform the instrument calibration technician and the appropriate staff member.

8. Measuring radiation levels in radioactive material work areas.

Radiation levels for routine survey purposes are measured 30 cm from surfaces of interest. Readings at this distance are recorded on the RP-315 Work Sheet for Radiation Surveys and on the RP-38 Radiation Survey Record. If the measurements are less than 0.05 mrad/hour (this is equivalent to 0.05 mR/hour on the Ludlum survey meters), then you merely place a check mark

on the survey sheets. If the measurements are in excess of 0.05 mrad/hour, then you record the actual measurement in mrad/hour. When you take radiation measurements with the Ludlum survey meter equipped with a Geiger-Mueller pancake probe, the meter reading needs no correction. When you use the NaI scintillation detector for ^{125}I measurements, use the following CPM to mrad/hour conversion factors:

24000 CPM	=	0.05 mrad/hour
240000 CPM	=	0.5 mrad/hour

Radiation levels at other distances must also be made to determine if contamination problems exist or if smaller radiation sources are present and unidentified. We expect that there will be some sources of radiation in many laboratories, especially where waste is stored and where people are actively working. You should verify that these levels are as expected - perhaps just slightly over background levels. On the other hand, you must further investigate radiation levels above background where you do not expect them, for example, sink basins, bench tops, the regular trash containers, and floors. These unexpected radiation levels above background may indicate the presence of improperly stored radioactive materials or fixed or loose surface contamination. If the radiation levels are due to improperly stored radioactive materials, have a radiation worker in the laboratory store them as required.

If the unexpected radiation levels are due to contamination it is important to discriminate whether it is loose or fixed. The contamination is fixed if wiping with a tissue or similar material, does not contaminate the wipe. If the wipe comes up contaminated, the surface was contaminated with loose radioactive material. If you have found loose surface contamination, you may have found evidence of a spill and there could have been a spread of contamination. You must verify that contamination has not been spread to other areas by measuring radiation levels especially carefully and taking additional wipe tests in areas adjacent to the original contamination, and by asking laboratory radiation workers if they can identify the source of the loose surface contamination. You must also ask them to survey themselves, clothing and shoes for contamination. If you find more areas of loose surface contamination, you may ask laboratory workers to decontaminate things; or, if the contamination is wide spread you may have to implement spill control procedures.

If the contamination is fixed, more aggressive decontamination methods may remove it. If there are still fixed levels of contamination after decontamination attempts, notify the appropriate staff member for assistance. Take a marker and mark the spot(s) where fixed contamination was found. You will be better able to describe the situation to the staff member if you know the maximum radiation levels, the distance from the source where they were measured, and how large an area is contaminated.
You may also be able to determine the isotope present. If the radiation levels decrease substantially, perhaps to background levels, when covered by a wipe test envelope, this may indicate ^{14}C or ^{35}S. If the radiation levels only decrease with thick plastic shielding, ^{32}P contamination may be indicated. If radiation levels are hardly affected by plastic shielding, a photon emitter like ^{59}Fe, ^{65}Zn, or ^{131}I may be the contaminant. These are not hard and fast relationships, especially for low levels of radioactivity, but they may be helpful. The best

reference for identifying the source of contamination may be the laboratory worker. Talk to him to see if he knows why radiation levels are higher than expected and whether contamination may have spread.

9. Obtaining wipe tests from radioactive material work areas.

The radiation survey described above may reveal the presence of some contamination, but not all; it certainly will not help in finding ^{3}H contamination. Wipe tests are obtained to complete our evaluation of the presence of radioactive contamination. Wipe tests for documentation purposes are taken with one inch filter papers. For each laboratory to be wipe tested, specific areas are wiped. These areas are assigned to a wipe test number. The wipe test number is linked to the computer print out from the liquid scintillation counters used to count wipe tests.

Wipe tests are taken where workers may handle radioactive materials to verify by our sampling technique that these areas are free of radioactive contamination. Common areas chosen for these wipe tests are bench tops, sinks, fume hoods, storage areas, waste receptacle areas, and other locations specific to the laboratory's use of radionuclides. We also wipe a prescribed surface area of 100 cm^2. This is well approximated by wiping a square of 10 cm by 10 cm (4" x 4") or wiping a line approximately 42 cm long (16"). This provides us a way to consistently evaluate radioactive contamination levels.

After you wipe the surface to be sampled, place the wipe test in the envelope that corresponds to that sample location. Once all wipes are taken, they are taken to the counting room for liquid scintillation analysis. The liquid scintillation counter output is logically connected to a spreadsheet program. The spreadsheet will provide the counting results in dpm/100 cm^2 and a worded description of the sample location. When you receive the completed counting results, you must see if there were contamination problems in the areas surveyed. You do so by looking for counting results in excess of our contamination limits of 200 dpm/100 cm^2 (100 dpm/100 cm^2 for radioiodine). If you find contamination approaching or above these limits, contact the staff member responsible for the project.

You may also want to take other wipe tests while performing your routine surveys. A large area wipe test is often useful in checking large surface areas such as floors, whole bench tops or hoods, etc. A large area wipe test may be obtained by simply using a tissue or paper towel and wiping a large area and counting it with your survey meter detector. Another useful large area wipe test is using a special oil-impregnated cloth on a floor mop. We store the mops and yellow maslin cloths in the radioactive package check-in room in Building E19.

10. Taking immediate corrective actions in laboratory for deficiencies found in survey.

Many concerns you identify may be handled at the time you find them during your survey. These include such things as:

* Instructing workers in the better radiological work practices to be employed in radioactive material handling, radiation surveys, radioactive waste reduction, and radioactive material storage and inventory.

* Asking radiation workers to correct some deficiency found by decontaminating a contaminated work area, completing a radioactive waste or radioactive material storage record, or properly labeling radioactive materials.

If you find that the workers in the Lab are not cooperative with you please report this to the RPP Staff. Also note that excessive fixed contamination must be reported to a staff member immediately.

11. Documenting survey and inspection findings.

In addition to documenting your surveillance results on the RP-315 and RP-38 forms, you must also update your survey record archives. Form RP-37 records the general information about the area surveyed.

The survey documentation and electronic archive is done through the RADIO database program for surveys. The RADIO database is kept on the Q drive and the survey program is located on the toolbar at the top of the page to the right. Choose "Survey Entry" and enter the building(s) and floors(s), and the lab level medium or low (m or l). Enter the information in the appropriate comment field and print the report. Check the information, update if necessary, and "add data" to the database. If there are any problems contact a staff member to correct it.

For each room surveyed, an RP-37 must be completed. Completion requires filling in the blanks appropriately, drawing the room floor plan and labeling the measurement locations, and updating the document periodically for changes. Changes include Authorization amendments which change radionuclides and their possession limits, or for redesignation of a laboratory as low level or medium level.

12. Preparing and counting wipe tests.

For routine wipe tests you are responsible for the preparation of the wipe samples for liquid scintillation counting. The steps are described briefly below. Wipe tests are counted with a liquid scintillation counter and the steps to do so effectively are listed below:

* Check with the RP Staff responsible for the counting room for available vials.
* Wipes are placed in plastic 20 milliliter vials
* 10 milliliters of liquid scintillation cocktail are added to every vial if not already done
* The vials are capped
* The vials are shaken to soak the wipe with cocktail
* The vials are placed in a cassette in the exact order of wipe test locations in the spread sheet program
* The vials are labeled with the appropriate option number to identify to whom they belong
* The vials are placed in the designated area for counting by RP Staff

After wipe tests are counted, the cassettes are emptied placed for RP Staff to mark and reuse or dispose of.

13. Filing completed survey records in RPP files.

Your original survey forms must be maintained for three years by DPH regulations. We actually keep them longer. Thus, you need to establish a set of binders for your completed survey records. Medium and low level laboratories are bound separately. All records except the RP-37 are archived on December 31. Black hanging binders are used for the LSC reports; red hanging binders are used for the RP-37; and blue hanging binders are used for the RP-315 and RP-38 forms.

14. Reporting survey findings to cognizant RPP staff.

It is extremely important that the cognizant staff person for the laboratory where deficiencies have been identified be notified of the concerns promptly. Deficiencies, including unexpected radiation levels, contamination, poor work practices, inadequate radioactive material security or inventory records, etc., must be reported to a staff member immediately on the day of occurrence. In your report, have all of the specific facts, such as dose rates, contamination levels, and the names of individuals involved.

It is also important to give copies of your surveys to the staff member to review even if there were no deficiencies. These copies will be provided on a monthly basis using the RADIO database "monthly summary" under Surveys.. This communication is vital because the staff person relies on your inspections for continuous quality assurance purposes.

15. Taking other corrective actions as appropriate for deficiencies not corrected in laboratory.

It may be necessary to take other, later, corrective actions besides those taken while in the laboratory. Your support of the staff member making decisions about further corrective actions is very important. Other corrective actions include things like the staff member contacting the project supervisor for changes in work practices, restricting personnel from radioactive material work, or shutting down certain laboratory activities.

Training Checklist

On the following page is a training checklist. This is used by the instructor to evaluate your performance. You will perform the training activity in an actual radiation laboratory after the instructor demonstrates and/or describes each skill or knowledge item involved. The training checklist will be retained in your training records to verify your training and the training=s effectiveness.

Rp-315 and RP-38
Rev. 4/01

MIT Radiation Protection Office - Survey Record

Week/Month #: 3

Date	Room	Des.	U/S	Auth	Area Survey Location 1	2	3	4	5	6	W	Waste Record	Instru-ments	Area Survey	Contam-ination	Eating or Drinking	Secur-ity	Wipe test Results	Comments
3/3/2016	68-640D	M	U	7-BQ	☑	☑	☑	☑	☑	☐	☑	☑	☑	☑	☑	☑	☑	☑	
3/3/2016	68-646D	M	U	7-BQ	☑	☑	☑	☑	☑	☐	☑	☑	☑	☑	☑	☑	☑	☑	
3/3/2016	68-646E	L	U	7-BQ	☑	☑	☑	☐	☐	☐	☑	☑	☑	☑	☑	☑	☑	☑	
3/3/2016	68-652D	M	U	7-BQ	☑	☑	☑	☑	☑	☐	☑	☑	☑	☑	☑	☑	☑	☑	
3/3/2016	68-653	M	U	7-AX	☑	☑	☑	☑	☑	☐	☑	☑	☑	☑	☑	☑	☑	☑	
3/3/2016	68-665	M	U	7-AC	☑	☑	☑	☑	☑	☐	☑	☑	☑	☑	☑	☑	☑	☑	
3/3/2016	68-683	M	U	7-AC	☑	☑	☑	☑	☑	☐	☑	☑	☑	☑	☑	☑	☑	☑	
3/3/2016	68-689	M	U	7-AC	☑	☑	☑	☑	☑	☐	☑	☑	☑	☑	☑	☑	☑	☑	

Waste Records: A check indicates waste records are up to date.

Survey Instrument: A check indicates instrument calibration is up to date and instrument is working.

Radiation Survey: Performed with GM equipped survey instrument. Measurements performed at several locations in lab as indicated in lab layout records. A check means that the general area dose rate is less than 0.05 mrad/hr. General area means 30 cm from any known source.

Contamination Survey: Performed with a GM equipped survey instrument for beta/gamma emitters. Measurement performed throughout the radiation lab on floors, equipment, benches, etc. A check means no detectable radioactive contamination or detectable contamination within acceptable limits and not requiring further acti

Eating/Drinking: A check indicates no evidence of eating or drinking in the laboratory.

Security: A check indicates one of the following:
a. the lab was locked
b. the lab was open and occupied by radiation workers and the stock material storage container was locked
c. experiment in progress signs are used for long term work where constant surveillance or locking the door is impractical

Actions: Whenever a noncompliance condition exists, a record of actions taken by surveyor are recorded. Completed worksheets are to be submitted to the RPP Staff responsible for that area. If unusual radiation or contamination levels are detected, contact the office immediately.

Signature of Technician: Beth Rice **Copies Given to Staff Member** **Option Number:** OPT68-6M

RP-37
Rev. 10/96

MIT Radiation Protection Program
Radiation Survey Cover Form

Room No. _____ Department _____

Lab Level _____ Supervisor _____

Auth. No. _____ Phone No. _____

Floor Plan with Survey Locations

Nuclide	mCi Poss. Limit	μCi/Experiment	Physical Form

Training Checklist

Instructions to the Instructor:

You must first demonstrate or describe each of the fifteen steps below. The extent of this demonstration is commensurate with the skills and knowledge of the person being taught. Then, use the guidance above to evaluate the performance of the technician being taught. Satisfactory performance means that the technician demonstrated his knowledge about the reasons for the steps to be taken, and perform those steps in accordance with the guidance above. The guidance above must have been provided to the technician for his review and preparation for training evaluation. Ask the technician if he has any questions about this guidance before evaluating performance. You are free to provide additional relevant instruction as the technician performs the task or answers questions. The training is to be completed in an actual radiation laboratory. Initial the Sat or Unsat space for each element. Describe reasons for any unsatisfactory mark below.

Element	Sat	Unsat
1. Obtained the necessary equipment, supplies and paper work.	____	____.
2. Entered laboratory looking for proper posting and security details.	____	____.
3. Described/observed proper radiological safety work practices expected.	____	____.
4. Described/inspected laboratory equipment for proper safety elements.	____	____.
5. Described/checked radioactive waste records.	____	____.
6. Verified adequate radioactive material storage security and inventory records.	____	____.
7. Verified operability of laboratory survey instruments.	____	____.
8. Measured radiation levels in radioactive material work areas effectively.	____	____.
9. Obtained wipe tests from radioactive material work areas effectively.	____	____.
10. Described/took proper immediate corrective actions for deficiencies.	____	____.
11. Documented survey and inspection findings completely and accurately.	____	____.
12. Prepared and counted wipe tests correctly.	____	____.
13. Filed completed survey records in RPP files correctly.	____	____.
14. Reported survey findings to cognizant RPP staff effectively.	____	____.
15. Described/took other corrective actions as appropriate for deficiencies.	____	____.

Technician completed all elements satisfactorily: Yes ____ No _____.
Reasons for Unsat performance (identify by training element number):

Instructor Signature: _____ Date:

Attachment 13 Lab Designation Guidelines

Laboratory Designation, Registration, and Termination Procedure for the Massachusetts Institute of Technology, Radiation Protection Program

1. Purpose
2. Guidelines for Designation of Laboratories Using Unsealed Radioactive Materials
3. Guidelines for Designation of Laboratories Using Sealed Radioactive Materials
4. Protocol for Laboratory Registration
5. Protocol for Laboratory Termination

1. The purpose of this procedure is to provide standardization of laboratory designation, registration, and termination. These are guidelines only, and can be adjusted at the discretion of the Radiation Protection Officer (RPO).

2. Guidelines for designation of laboratories using unsealed radioactive materials:
    a. Generic use limits: These limits are based upon Appendix C values from 105 CMR 120.297 for each radionuclide, with the exception of some commonly used radionuclides. For these possession limits, refer to section 2.b.

Generic Use Limits: Unsealed Radioactive Materials	
Room Designation	**Use Limits**
Tracer Level	$10^0 \rightarrow 10^1 \times$ App. C value
Low Level	$10^1 \rightarrow 10^2 \times$ App. C value
Medium Level	$10^2 \rightarrow 10^3 \times$ App. C value
High Level	$> 10^3 \times$ App. C value
Note[1]: If App. C value is ≥ 100 μCi the use limit is reduced by a factor of 0.1. Note[2]: If a laboratory uses more than one radionuclide, the minimum App. C value for the radionuclides is used.	

    b. Specific use limits:

Specific Use Limits: Unsealed Radioactive Materials					
Radio-nuclide	**App. C Value**	**Laboratory Designation**			
		Tracer Level	**Low Level**	**Medium Level**	**High Level**
^{3}H	1000 μCi	<1 mCi	1 → 100 mCi	0.1 → 1 Ci	> 1 Ci
^{14}C	100 μCi	<100 μCi	0.1 → 10 mCi	10 → 100 mCi	> 100 mCi
^{32}P	10 μCi	<100 μCi	0.1 → 1 mCi	1 → 10 mCi	> 10 mCi
^{35}S	100 μCi	<100 μCi	0.1 → 10 mCi	10 → 100 mCi	> 100 mCi
^{51}Cr	1000 μCi	<100 μCi	0.1 → 10 mCi	10 → 100 mCi	> 100 mCi
^{125}I	1 μCi	<10 μCi	0.01 → 1 mCi	1 → 10 mCi	> 10mCi
Note[1]: If App. C value is ≥ 100 μCi the use limit is reduced by a factor of 0.1. Note[2]: If a laboratory uses more than one radionuclide, the minimum App. C value for the radionuclides will be used.					

3. Guidelines for designation of laboratories using sealed radioactive materials:
   Definitions and descriptions of sealed radioactive materials:

    a. A sealed source is defined as a source that has been fabricated as a sealed source in accordance with NRC or agreement state licensing requirements.
    b. In general, a contained source will be considered unsealed radioactive material. However, sealed source guidelines may be applied to a contained source when the source is judged to be adequately fabricated and encapsulated to prevent leakage.
    c. Leak-tests of sealed sources according to license requirements will not be waived in lieu of laboratory contamination surveys.

   Laboratories using sealed sources only may be designated as a Sealed Source Laboratory. Areas in which the sealed sources are used within Sealed Source Laboratories will be appropriately marked. The areas of sealed source work are governed by the RPP "No Eating or Drinking" policy. The remainder of laboratory space is free of such constraints. Sealed Source Laboratories will be surveyed by RPP biannually. Gamma cell irradiator facilities are surveyed monthly.

4. Laboratory registration: Follow the guidelines set forth in sections 2 and 3 for determination of laboratory designation. It is good radiation protection practice to assign at least one medium level laboratory for each authorization using more than one laboratory; it should be the laboratory using the greatest amount of radioactivity or work activity.

   General procedure for listing new laboratories:
    a. Obtain a listing of all laboratories designated to use or store radioactive material from the "Application for Authorization to Possess and Use Radioactive Material," form RP-01.
    b. Follow the general procedure set forth in section 2 and 3 to properly designate each laboratory.
    c. Fill out work sheet RP-09, Section A, according to the instructions on the form.
    d. Sign and date the form, and submit it to the RPP administrative coordinator for processing.
    e. The RPP administrative coordinator will enter changes on the RPP laboratory database, and return the work sheet to the signatory staff member.

   General procedure for changes in existing laboratory designations:
    a. Obtain a request of all laboratories designated to use or store radioactive material to be changed from the project supervisor or RPP staff member as applicable.
    b. Follow the general procedure set forth in Section 2 and 3 to properly designate each laboratory.
    c. Fill out work sheet RP-09, Section B, according to the instructions on the form.
    d. Sign and date the form, and submit it to the RPP administrative coordinator for processing.
    e. The RPP administrative coordinator will enter the updated information on the appropriate page of "Listings of Rooms in Which Radioactive Material is Stored or Used," form RP-38; copy the updated page and distribute it to RPP staff; enter the appropriate room change on the corresponding authorization; and return the form to the signatory staff member.
    f. Meet with the RPP technician responsible for that area and assign duties accordingly (e.g., lab posting, equipment markings, survey frequency, etc.).
    g. File form RPP-09 properly for future reference.

5. Laboratory termination general procedure:

    a. Obtain a request of all laboratories designated to use or store radioactive materials that are to be terminated from the project supervisor or RPP staff member as applicable. Confirm that a lab termination survey has been performed.
    b. Fill out work sheet RP-09, Section C, according to the instructions on the form.

c. Sign and date the form, and submit it to the RPP administrative coordinator for processing.
d. The RPP administrative coordinator will enter the updated information on the appropriate page of "Listings of Rooms in Which Radioactive Material is Stored or Used," form RP-38; copy the page and distribute it to RPP staff; enter the appropriate room change on the corresponding authorization; and return the form to the signatory staff member.
e. If the authorization is to be terminated, fill out form RP-011, "Authorization Termination Checklist," and submit it to the responsible technician.
f. Meet with the RPP technician responsible for that area and assign duties accordingly (e.g., lab posting removal, equipment survey, close-out survey, waste removal, etc.).
g. File form RP-09 properly for future reference.

Use of Hazardous Materials in Animals

This form may be submitted in support of a protocol application or separately, as an addendum, to describe the use of **hazardous materials** in animals. If this is an addendum, please also submit the Addendum Cover Letter form found on the CAC website: https://web.mit.edu/comp-med/restrict/cac/forms.htm.

1. Fill out one form for each hazardous agent (biological, chemical including nanoparticles, radioactive) unless agents are closely related (e.g., similar radioisotopes may be combined) or two agents will be administered together (e.g., radiolabeled chemical agent).
2. Investigators must obtain RPP authorization for radioactive hazards and a Biological Project Registration number for biological hazards from EHS before the CAC can approve this research.
3. Do not refer to other sections of the CAC protocol. EHS receives this form only and it must contain all details of dosing, time points, etc.
4. For general information regarding hazardous agents, call the MIT EHS at x23477 or WIBR EHS at x85212.

Section 1: General Info.

Principal Investigator (PI):		Contact Person(s):	
PI Phone:	PI Email:	Contact Phone(s):	Contact Email(s):
CAC Protocol Number:	Department:	Lab Address:	

Type of Hazard

BIOLOGICAL HAZARD Name:	Biological project registration number:
Amount kept in laboratory:	
CHEMICAL HAZARD* (including nanoparticles) Name:	Storage location and physical state:
Method of preparation and amount:	Source:
RADIOACTIVE HAZARD Isotope(s):	RPP authorization number for PI:
Total amount of activity (µCi) per experiment and per animal:	Preparation/chemical form:

*Attach MSDSs for ALL chemical hazards and relevant scientific literature to clarify occupational health risk.

Administration of Multiple Hazards

If an individual animal will receive hazards described on another Supplement I in addition to those listed above **at any time**, then list the other hazardous agents here.**

**Describe the time interval(s) between dosing with the different hazards within the Manipulations and Procedures section.

Section 2: Personnel Training

List all personnel handling hazard (on separate lines):	List pertinent EHS (MIT and/or WIBR) training and date received:

Training history is available at the EHS website: http://we.mit.edu/environment/training/ or from WIBR EHS. Appropriate courses may include **Radiation Safety**; Chemical Hazards (**General Chemical Hygiene** and **Managing Hazardous Waste**); and **Biosafety/Bloodborne Pathogens**. All personnel must be CAC-certified and an approved participant on the CAC protocol cited above.

Section 3: Administering Hazard

Do not refer to other sections of the CAC protocol. EHS receives this form only and it must contain all details of dosing, time points, etc.

Give specific details of:

A. Animal species (indicate strain and/or genetic modification): **AND** quantities per year:	
B. Dose per animal (amount per unit body weight): **AND** total volume per dose:	
C. Route of administration:	
D. Frequency of dosing: **AND** total number of doses:	
E. Survival time after dosing (how long before animal is euthanized?):	

Section 4: Manipulations and Procedures

Do not refer to other

Describe all manipulations to prepare the material for dosing. Administration by any route other than orally requires a sterile prep (default should include filtration through a 0.22 micron filter):

Provide details on administration of the hazardous material to the animal(s). Indicate any other animal

sections of the CAC protocol. EHS receives this form only and it must contain all details of dosing, time points, etc.

manipulations that are planned after the hazard have been administered (e.g., surgery, transport out of animal facility, behavioral testing, etc.), including procedures at necropsy unique to the hazardous material. **If additional hazards will be used in the same animal**, then describe time intervals between dosing with the different agents:

If any of the above procedures will be performed outside of DCM animal facilities, indicate which procedures, and list those locations and how animal(s) are transported:

Section 5: Agent/Metabolite Excretion/ Secretion or Propagation

Provide amounts (chemical and/or biological hazards) or activity (radioactive hazard) expected to be excreted/secreted. Appropriate scientific literature must be consulted to complete this section; any answer of "unknown" must be substantiated:

Urine:	Feces:	Expired air:
Secretions (be specific):	Duration of excretions/secretions:	
Method of detecting agent/metabolite:	List metabolites to be excreted/secreted:	
Are any metabolites hazardous? If yes, which ones?	Are any metabolites volatile? If yes, which ones?	
List references/sources of information on metabolites and excretion/secretion:		
For **biological hazards**, will the agent replicate in the animal? How is this monitored? Provide references:		

Federal regulations require that compounds used in research animals, including those used in non-survival procedures and euthanasia, be pharmaceutical grade. A pharmaceutical-grade compound is a drug, biologic, or reagent approved by the United States Food and Drug Administration (FDA) or for which a chemical purity standard has been established by a national or regional pharmacopeia, such as the United States Pharmacopeia-National Formulary (USP). Non-pharmaceutical (chemical- or reagent-grade) compounds are purchased as raw material with unknown sterility or expiration date. The CAC policy on use of non-pharmaceutical grade (NPG) materials, including how exemptions are justified, should be reviewed on the CAC website under Policies.

Section 6: Pharmaceutical Status of Drugs or Chemical Compounds

Confirm drugs, compounds, and the dosing vehicle (i.e., PBS, DMSO, etc.) are pharmaceutical-grade (USP), or provide justification for using non-pharmaceutical grade (NPG) compounds in animals. Justification for NPG compounds should include scientific necessity and non-availability of USP equivalent (see Policy on CAC website for other justifications).

Provide assurance that non-pharmaceutical compounds will be prepared sterile if delivered by injection (describe sterility methods; e.g., 0.22 micron filtration) and will be labeled with a reasonable expiration date. Also, verify that characteristics such as pH, pyrogenicity, osmolality, compatibility of components, and pharmacokinetics will be compatible with animal physiology.

Section 7: Compliance Statement

I affirm the accuracy of all the information on this "Use of Hazardous Materials in Animals" form.

I agree that **hazard use in animals cannot start** until the following has occurred, in listed order:

1. The CAC has approved the corresponding protocol application/addendum that describes the use of hazardous materials in animals.
2. A specific "DCM Protection/Control Required for Hazard Use in Animals" form for each particular hazard has been generated by DCM and EHS.
3. Study personnel listed on this form have been contacted by the DCM Hazards Coordinator (Dr. Mary Patterson, mmpatt@mit.edu, x45403) or designee for consultation, space allocation, and orientation in the animal facility on the use of each particular hazard in animals. This training needs to occur shortly before the study is initiated; retraining may be required if the study is delayed.
4. Study personnel joining subsequent to the initial orientation should not contact Dr. Patterson for "hazmat" training until they have been notified by the CAC that their NPA to join the protocol is approved.

Principal Investigator (print name): Date:

Signature:

Attachment 15 Radioactive materials use in animals

Procedures Required for Animal In Vivo Experiments Involving Radioactive Materials

1. The project must have a protocol approved by the Radiation Protection Program (RPP) and the Division of Comparative Medicine (DCM) prior to performing experiments using radioactive materials with animals. Submit to DCM a completed Supplemental I "Use of Hazardous Materials in Animal" form (see attached) describing the proposed research. The hazardous materials form can be obtained from the DCM and will require specific information pertaining to the experiment

Note: This also applies to protocols that have been previously approved. When any changes are made to the previously approved protocol, please notify the RPP, who will decide whether a new hazardous materials application is required to be filed with the DCM.

2. The Committee on Animal Care (CAC) approved Supplemental I "Use of Hazardous Materials in Animal" form is sent to RPP for review RPP must review the animal protocol and approve the radiation safety elements to be used during the experiment. This approval is and conditions are documented on a "Required Protection/Control for Hazard Use in Animal" (PCR) form. The approved form is returned to DCM.

3. Any radioactive waste that contains potentially biohazardous or carcinogenic material must be inactivated prior to its disposal as radioactive material waste.

4. Should there be a possibility of the release of airborne radioactive contamination during injection, housing or sacrifice, an approved hood or exhaust ventilated enclosure shall be used. This procedure must be approved by the RPP.

5. Only trained radiation workers may perform work with radioactive materials. All researchers involved in the animal work must be listed on the protocol.

6. Animals shall be injected with radioactive materials and housed or sacrificed in rooms authorized by the RPP.

7. The protocol must include specific amount of radioactivity used per animal, total activity per experiment, animal weight, sacrificed frequency, and total number of animals. Make sure that a precise estimate of the frequency and time frame of the experimental research is given.

8. Injection of animals shall be done in a manner that will confine any accidental spill of radioactive materials. For example, injections should be performed on a spill tray or surface covered with bench paper.

9. Animals should be housed in metabolic cages, when possible. This eliminates the need to use animal bedding.

10. Animals shall be sacrificed such that all potentially radioactive tissues and body fluids are collected and stored as radioactive materials for further analysis or disposed of as radioactive waste. If they are to be disposed of, carcasses and tissues shall be placed in plastic bags and placed in the appropriate animal freezer designated by the RPP. The certification tag shall be placed on each bag.

11. The animal cages shall be labeled with a "caution radioactive materials" sign. Copies of the "PCR/Hazamt forms and any other special forms are posted outside the cubicle where the animals are housed.

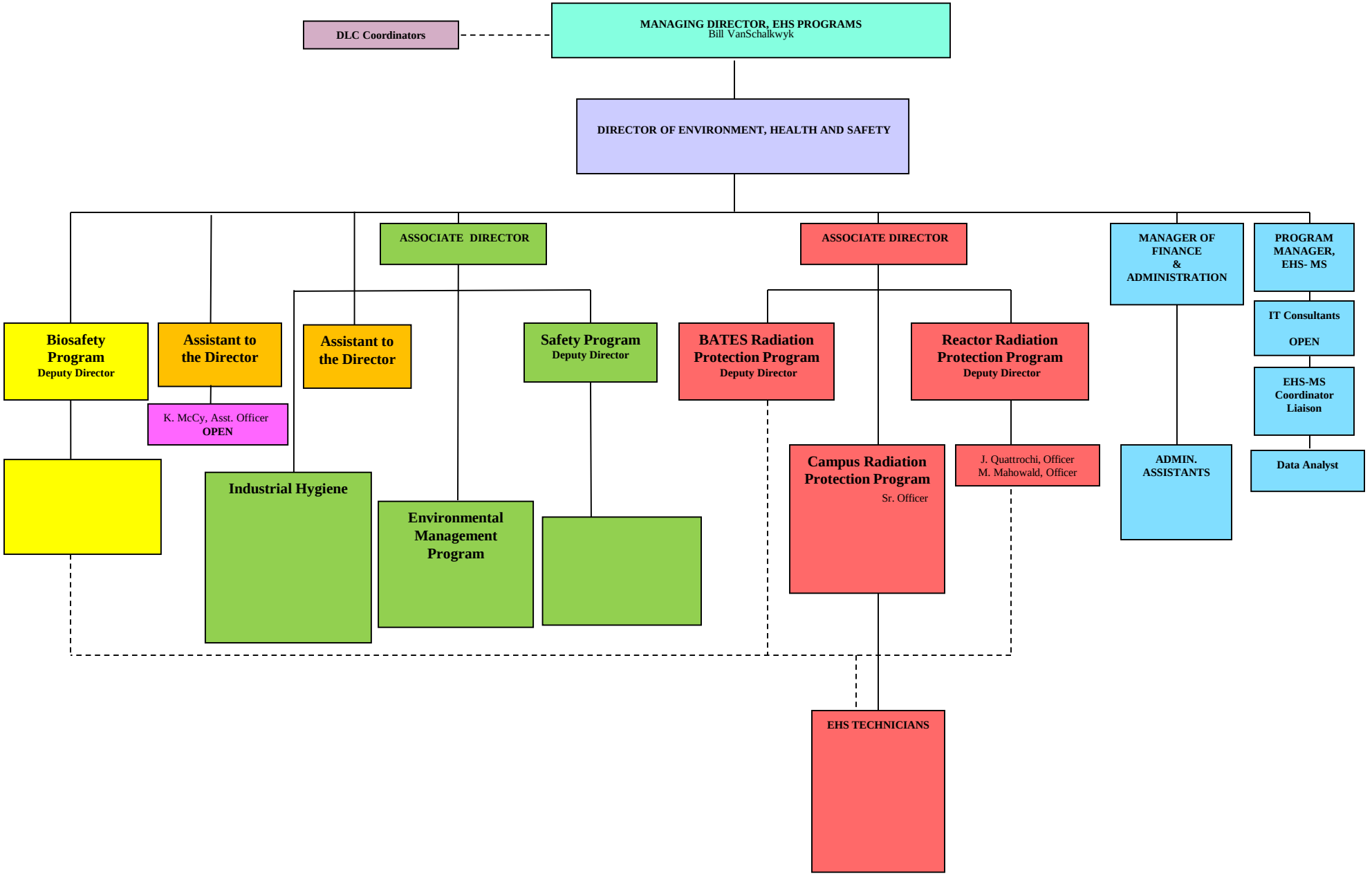
12. The husbandry of the animal is the responsibility of the researcher. The researcher shall survey and/or wipe test the cages and decontaminate as necessary. The DCM shall cage wash contamination free cages.

13. All radioactive solid and liquid waste shall be put into the appropriate waste containers set-up by the RPP. A record of the nuclide, amount of waste, and date shall be maintained.

14. All applicable radioactive water soluble or dispersible material shall be disposed of via the sanitary sewage system as per regulations. Animal excreta, especially for the long lived radionuclides, shall be disposed of in drains equipped with garbage disposal type equipment on the drain line so the animal excreta can be homogenized prior to disposal.

15. Animal carcasses containing ≤ 0.05 μCi of ^{3}H or ^{14}C per gram of tissue averaged over the weight of the entire animal may be disposed of without regard to its radioactivity. This waste shall be disposed of with the other non-radioactive animal waste.

EHS Organizational Chart – February 1, 2016



Note: *Indicates not a FTE

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

RADIATION PROTECTION PROGRAM

REQUIRED PROCEDURES FOR RADIATION PROTECTION

Seventh Edition (interim)
January 2006

ISSUED BY THE MIT RADIATION PROTECTION COMMITTEE

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

REQUIRED PROCEDURES FOR RADIATION PROTECTION

Preface

Radiological health and safety at the Massachusetts Institute of Technology is controlled by the MIT Radiation Protection Committee, a presidentially appointed committee composed of senior faculty and administrators. The requirements of the RPC are delineated in these Required Procedures for Radiation Protection. The required procedures are administered by the Radiation Protection Program (RPP), a staff of health physicists, radiation protection technicians, and administrative support personnel functioning as the operational arm of the RPC.

Under the direction of the MIT Radiation Protection Officer, radiological safety is managed at the Cambridge campus, the Bates Linear Accelerator Laboratory, and the MIT Research Reactor. RPP may be reached at the following telephone extensions: Campus (3-2180), Nuclear Reactor (3-4203), and Bates Linear Accelerator (3-9217). After hour or weekend emergency notification is provided through Campus Police (100) or Work Control (3-1500).

The RPP provides health physics and radiation safety services to all persons using sources of ionizing and non-ionizing radiation. Projects using radioactive materials are authorized through the RPP in accordance with Commonwealth of Massachusetts Department of Public Health license conditions. The following services related to the safe use of unsealed radioactive materials and sealed sources are provided by RPO:

* **training of all radiation workers, emergency personnel and ancillary workers;**
* **monitoring workers for external and internal radiation exposures;**
* **radioactivity analysis;**
* **environmental monitoring for potential releases of radioactive material;**
* **routine surveillance for radiation and contamination in radiation laboratories;**
* **calibration and repair of radiation survey instrumentation;**
* **collection, disposal, and management of low level radioactive waste;**
* **design and construction of radiation shielding; and**
* **assistance in the design of radiation laboratories.**
* **24 hour emergency response**

Registration, worker training, and surveillance are also part of the established RPP programs for safe use of analytical x-ray equipment, medical x-ray units, and high dose irradiators. A laser safety program which requires registration of all lasers, worker training, and laser safety evaluations is maintained by RPP. With respect to other non-ionizing radiation, RPP measures and evaluates electromagnetic radiation field strengths from sources such as VDTs, power lines, microwave generators, radar installations, and magnetic imaging devices.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

REQUIRED PROCEDURES FOR RADIATION PROTECTION

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MASSACHUSETTS INSTITUTE OF TECHNOLOGY

REQUIRED PROCEDURES FOR RADIATION PROTECTION

1. PURPOSE

    1. The required procedures contained in this document have been established for the following purposes:

        1. To provide for the protection of the Institute population and of the general public against radiation hazards associated with MIT's possession, use, transportation, and disposal of radioactive material.

        2. To provide for the Institute's compliance with applicable radiation protection regulations of Federal, State and Local governmental agencies.

2. DELEGATION OF AUTHORITY

    1. The Radiation Protection Committee (RPC) receives its authority from the Office of the President of MIT.

    2. The Committee is charged with the following responsibilities:

        1. The establishment and continuing review of an adequate radiation protection program at the Institute and its off campus sites.

        2. The Institute's compliance with radiation protection regulations promulgated by governmental agencies.

        3. Auditing at least annually of the Radiation Protection Program.

    3. To meet these responsibilities, the RPC has been given the following authority:

        1. To grant authorization to an individual, project, or department for the use of radioactive material on MIT property or at MIT field sites.

        2. To suspend an individual's or project's MIT authorization to use radioactive material.

        3. To apply restrictions on the amount of occupational radiation exposure that an individual may receive during his MIT association.

        4. To apply conditions of approval that must be adhered to with the project's proposed uses of radioactive materials.

    4. The Radiation Protection Program, under the direction of the Institute Radiation Protection Officer, of the Medical Department's Environmental Medical Services has the following responsibilities:

1. Implementing the Institute's radiation protection program.

2. Operating the Institute's Central Radioisotope Laboratory and Storage Facility.

3. Providing such services as may be required for radiation protection and compliance with governmental regulations. The services include the following:

    1. Registration and training of radiation workers.

    2. Training of ancillary personnel.

    3. Personnel monitoring of internal and external radiation exposure.

    4. Radioisotope laboratory inspections, audits and radiation surveys.

    5. Radioactive waste collection, management, measurement and disposal.

    6. Calibration and repair of radiation protection survey instruments.

    7. Approval of all purchases of radioactive material.

    8. Environmental monitoring.

    9. Leak testing and physical inventory of sealed radioactive sources.

    10. Monitoring and laboratory delivery of incoming shipments of radioactive material.

    11. Preparation and monitoring of outgoing shipments of radioactive materials.

    12. Supervision of radiation emergencies, and special decontamination operations.

    13. Operation of an MIT vehicle for transportation of radioactive material.

    14. Maintenance of radiation protection records.

4. In addition, the Radiation Protection Program staff is available for:

    1. Consultation on laboratory design, shielding, and other radiation exposure control methods, and

    2. Presenting lectures and training exercises on radiation protection techniques.

5. Each Department, Laboratory, and Project Supervisor is responsible for providing adequate facilities, equipment, instruments, supervision, and instructions to control radiation hazards and to comply with the Institute's radiation protection requirements.

6. Each Project Supervisor possessing or using radioactive material or radiation sources has the following responsibilities:

    1. Maintaining an up-to-date listing with the Radiation Protection Program of rooms in which radioactive material is stored or used.

    2. Maintaining an up-to-date listing with the Radiation Protection Program of the names of personnel who may use radioactive material.

    3. Allowing only those persons who are registered with, and trained by, the Radiation Protection Program to use radioactive material.

    4. Promptly completing and returning authorization renewal packages and scheduling retraining sessions.

    5. Providing experiment-specific training to radiation workers in their laboratories.

    6. The maintenance of an adequate written inventory of the amount of radioactive material possessed and the establishment of an adequate system to alert the project of any deliberate diversion of radioactive material.

    7. Establishing procedures to comply with the institute policies for security of radioactive materials.

    8. Keeping adequate records of disposal of radioactive material on forms that are supplied by the Radiation Protection Program.

    9. Allowing only authorized persons to enter rooms that are specified as restricted areas for reasons of radiation protection.

    10. Informing the Radiation Protection Program of new radioactive material work, or changes in existing work, which may potentially increase radiation exposure.

    11. Ensuring that personnel wear assigned personnel monitoring devices during periods of possible exposure and the timely exchange of used dosimeters with the RPO.

    12. Establishing appropriate procedures to ensure compliance with the Caution sign and labeling requirements of Section III.K. of this document.

    13. Establishing routine radioisotope laboratory monitoring procedures adequate to ensure that the following conditions exist at the conclusion of work with radioactive materials:

        1. Survey meter measurements have established that external radiation and contamination levels are within permissible limits and as low as reasonably achievable.

2. Radiation sources are properly labeled, stored and secured.

3. Experiments that will be in progress after normal work hours, will be properly attended and posted.

4. Each laboratory is secured against unauthorized access.

5. Records are maintained as required by the Radiation Protection Program.

7. Each individual who may use radioactive material has the following responsibilities:

1. Complying with the procedures and precautions contained in this document, and with those established by his/her Project.

2. Complying with the conditions of approval found in the project's authorization.

3. Handling radioactive material in a responsible manner to maintain occupational radiation exposure as low as is reasonably achievable.

4. Notifying the RPP of any emergency, spill or personnel contamination involving radioactive material.

5. Informing the RPP prior to transferring any radioactive material between authorized projects. Transfers must be approved by the RPP and the transfer must be documented in the project's inventory control system.

3. REQUIRED PROCEDURES PERTAINING TO RADIOACTIVE MATERIAL

1. Scope

1. These procedures apply to all departments, laboratories, and persons at the Institute or at its off-campus sites that receive, possess, use, transport, or dispose of radioactive material.

2. Control of Radiation Exposure and Contamination

1. Exposure to ionizing radiation shall be kept as low as is reasonably achievable (ALARA). See Appendix 7 for MIT's ALARA Program.

2. Occupational external and internal exposure from radioactive material shall be controlled such that no individual shall receive a radiation dose in excess of the values listed in Appendix 1.

3. Compliance with Regulations of Governmental Agencies

1. The use, storage, transfer, transportation, and disposal of radioactive material must conform with the applicable regulations of the Massachusetts Department of Public Health (MDPH), the US Nuclear Regulatory Commission (NRC), and the US Department of Transportation (DOT).

2. The applicable regulations are as follows:

    1. NRC Title 10, Code of Federal Regulations, Part 20

    2. MDPH "Rules and Regulations to Control the Radiation Hazards of Radioactive Material and of Machines Which Emit Ionizing Radiation", CMR 120, Section 5B, Chapter III, General Laws

    3. DOT Title 49, Code of Federal Regulations

4. Registration and Authorization

    1. Prior to possessing or using radioactive material on MIT property, authorization must be obtained from the Radiation Protection Committee. The procedure for obtaining authorization and the procedures for procuring radioactive material are described in Appendix 3.

    2. Each room or laboratory in which radioactive material is to be handled or stored must be registered with the Radiation Protection Program and approved for such use by the Radiation Protection Program.

    3. Each person who may work with or handle radioactive materials must register with the Radiation Protection Program. Worker registration consists of completion of the form entitled "Registration and Radiation Record", attendance at an RPP radiation safety training course, and successful completion of a written examination demonstrating adequate radiation safety knowledge.

    4. Each user must be approved for a proposed use of radioactive material with specific regard to the adequacy, for the proposed use, of his/her training and experience.

    5. In general, undergraduate students using radioactive materials as part of an undergraduate course will be under the supervision and in the physical presence of an instructor approved by the Radiation Protection Committee. One exception to this rule is when small numbers of students undertake specific projects involving long-term use of small quantities of tracer material. Such students (usually seniors) are specifically trained for this work, are registered as radiation workers, and are only authorized to undertake such projects when RPP is satisfied that their potential for exposure is within limits suitable for such students.

5. Bioassay Tests, Including In Vivo Measurements

    1. Depending on radiation exposure history and proposed work at MIT, persons registering with the Radiation Protection Program may be given appropriate bioassay tests to determine body burden of radioactive material prior to starting such work at MIT. Subsequently, as required by the Radiation Protection

Program, periodic bioassay tests shall be performed.

2. In the event of accidental internal deposition of radioactive material, bioassay tests shall be performed as appropriate.

3. The action levels for bioassay measurement results are as follows:

    1. Investigation action levels: Any measurement result that exceeds 5% of the annual limit on intake (ALI) initiates an investigation to evaluate the source of the exposure and the means of improving handling techniques. All such investigations will be fully documented.

    2. Administrative action levels: Any measurement result that exceeds 25% of the ALI would initiate suspension of the work operations until satisfactory control measures are implemented.

4. Failure of a radiation worker to comply with the bioassay submission deadline will result in a notification to his supervisor of the suspension of that worker's permission to work with the involved radioactive material until a satisfactory bioassay measurement has been obtained.

5. The bioassay submission criteria and deadlines for radionuclides are as follows:

    1. Unsealed alpha, beta, and/or gamma emitters other than unbound radioiodine and tritium: People working with more than 10 times the Annual Limit on Intake at any one time, appropriate bioassay is required within 5 working days for infrequent users and monthly for those performing procedures routinely. Typically, urinalysis for alpha or beta emitters, and in vivo measurements for gamma emitters.

    2. Unbound radioiodine: Thyroid burden measurements are scheduled monthly for persons routinely handling 0.1 - 20 mCi of ^{125}I and/or ^{131}I and within 5 working days for handling more than 20 mCi. For occasional users (less than one iodination per month) handling more than 0.1 mCi, thyroid measurements are performed within 5 working days.

    3. Tritium: individuals who use more than 10 mCi of ^{3}H in a non-contained form, other than metallic foil, are scheduled for urinalysis within:

        (1) Five working days following a single operation,

        (2) One month intervals for continuous operations,

        (3) One week intervals for handling more than 100 mCi routinely, and

        (4) Daily for handling one curie or more routinely.

6. Radiation Surveys and Monitoring

1. Each project/laboratory using radioactive material must have appropriate radiation detection instruments.

2. When significant radiation levels or contamination are possible, personnel shall use an appropriate radiation detection instrument to establish that radiation exposure and contamination spread are being adequately controlled.

3. Radiation workers will perform "close down" radiation surveys at the end of each use of unsealed radioactive material. The survey will include contamination measurements of the worker's lab coat/clothing, the laboratory surfaces where the radioactive material was handled, and the adjacent areas/equipment.

4. The Radiation Protection Program will provide each radiation worker who may receive a radiation dose in excess of 10% of the limits of Appendix 1 with appropriate personnel monitoring badges.

5. When provided, personnel monitoring badges shall be worn in the manner specified by the Radiation Protection Program whenever occupational radiation exposure may be received. When not being worn, the badges shall be stored in a location where they will receive minimal radiation exposure above background.

7. Storage/Security of Radioactive Material

    1. Radioactive material shall be stored/secured as follows:

        1. All stock/stored radioactive material will be stored in a locked container (e.g. freezer, refrigerator or secured locked box). The container will remain locked at all times except when material is being accessed from the locked container.

        2. An accurate record of the inventory/use of stock/stored material will be kept at the secured storage location.

    2. Radioactive material shall be stored in a manner that:

        1. Provides adequate radiation shielding.

        2. Provides adequate protection against fire, explosion, or flooding.

        3. Provides adequate protection against accidental breakage of primary storage containers.

    3. Radiation laboratories will be locked when all radiation workers have left the area and at the end of each workday.

8. Transportation of Radioactive Material

1. Pedestrian transportation within MIT Property boundaries

    1. Radioactive material may be hand-carried outside of laboratory areas, and between buildings within MIT property boundaries, provided that the following conditions are met:

        (1) The radioactive material is doubly contained and the outer container is a shatter-proof container that is properly labeled.

        (2) The emitted radiation dose rate does not exceed the following levels:

            (1) 50 mrad/hour at any point of readily accessible surface of the container, and

            (2) 2 mrad/hour at 1 meter from any point on the accessible surface of the package.

        (3) There is no detectable contamination on the container's exterior surface as determined by an appropriate wipe test and survey meter measurement of the wipe test.

        (4) During transit, the radioactive material is always in the possession and responsible charge of an individual who is authorized to use or to transport the material.

2. Pedestrian transportation between MIT buildings where the route includes public roadways.

    1. Radioactive material may be hand-carried between buildings of the MIT complex over routes that include public streets and sidewalks provided that the following conditions are met:

        (1) The conditions of (1), (2), (3), and (4) of Section I.1.(a) above are met, and

        (2) The transportation container is approved by the Radiation Protection Program as being in conformance with DOT specifications, and

        (3) The total activity being carried does not exceed 1000 times the value specified in Appendix 5, unless otherwise authorized by the Radiation Protection Program.

3. Pedestrian transportation outside of the MIT complex

    1. There will be no pedestrian transportation of radioactive materials outside of the MIT complex without specific approval of the Radiation Protection Program.

4. Transportation of radioactive material by mail or by vehicle

    1. The mailing or transporting of radioactive material shall be done in a manner that is approved by the Radiation Protection Program as being in compliance with appropriate governmental regulation (i.e., DOT or Postal regulations).

    2. Vehicular transportation of MIT-possessed radioactive material shall be conducted as follows:

        (1) Unless otherwise approved by the Radiation Protection Program, an MIT-owned vehicle or a commercial carrier must be used.

        (2) For local transportation, a privately owned vehicle may be used, only if specifically authorized by the Radiation Protection Program.

        (3) All persons transporting radioactive material in private vehicles must attend a safety training course in transportation provided by the Radiation Protection Program.

    3. Transportation to other licensed facilities and institutions

        (1) Radioactive material may be transported to non-MIT facilities provided that the following conditions are met:

            (1) The project notifies the Radiation Protection Program of, and secures prior to approval for, all transportation and transfers, and

            (2) The Radiation Protection Program has a current copy of the facilities radioactive materials license.

9. Disposal of Radioactive Material

    1. Radioactive material must be disposed of in accordance with the provisions of Appendix 3.

    2. Incineration of radioactive waste is not permitted at MIT under current State licenses.

10. Transfer of Possession of Radioactive Material Between MIT Departments or Projects

    1. Radioactive material shall not be transferred outside of a project without the prior authorization of the Radiation Protection Program.

    2. A record of all authorized transfers must be kept with the project's inventory control records.

11. Caution Signs and Labels

1. Laboratory Posting of Caution Signs

1. The entrance to each laboratory storing or using radioactive material shall be posted by the Radiation Protection Program with appropriate caution signs in conformance with 105 CMR 120. These signs shall be removed only by, or with the approval of, the Radiation Protection Program.

2. Each sign that is posted by the Radiation Protection Program will contain a section in which emergency notification information is to be inserted by the project. It is the Project Supervisor's responsibility to ensure that the appropriate emergency notification information is inserted and kept up-to-date.

3. The Radiation Protection Program shall be notified when posted caution signs needs replacement or removal.

2. Labeling of Containers

1. Each container of radioactive material will be labeled by the user in conformance with the following procedures, which meet state regulations:

(1) Unless exempted by the Radiation Protection Program, each container holding radioactive material in excess of those quantities listed in Appendix 5 must have a durable, clearly visible label bearing the radiation caution symbol and the words: "CAUTION RADIOACTIVE MATERIAL"

(2) The color and design of the label are specified in 105 CMR 120. These labels must also state the quantities and kinds of radioactive materials in the containers and the date of measurements of the quantities.

(3) Each container holding less than those quantities listed in Appendix 5 should be identified with the words "Radioactive Material" and the principal radionuclide specified.

(4) Labeling is not required for laboratory containers, such as beakers, flasks, and test tubes used transiently in the laboratory procedures while the user is present.

(5) For purposes of these labeling requirements, where there is involved a combination of isotopes in known amounts, the limit of the combination will be derived as follows:

(1) Determine for each isotope in the combination, the ratio between the quantity present and that quantity listed for the nuclide in Appendix 5.

(2) The sum of such ratios for all radionuclides in the combination may not exceed 1.

12. General Radiation Protection Requirements and Precautions

1. There shall be no smoking, eating, drinking, storage of food, or use of cosmetics in any area where unsealed and unpackaged sources of radioactive materials are being used, handled, transferred, or stored.

2. There will be no mouth pipetting of radioactive solutions in any area where unsealed and unpackaged sources of radioactive materials are being used, handled, transferred, or stored.

3. Whenever practical, the user should perform a trial experiment run using stable (or low activity) material to establish the adequacy of procedures and equipment.

4. Prior to performing an operation on a source of radioactive material, radiation levels will be measured. Handling tongs, or a suitable remote handling device must be used for handling a source or container that emits a dose rate, at contact, in excess of 1000 mrad/hr unless otherwise specifically authorized by the Radiation Protection Committee.

5. When performing operations that might produce airborne contamination (i.e., evaporations, sanding or grinding, transfers of unsealed powdered or volatile radioactive material), approved exhaust ventilation shall be used. When recommended by the Radiation Protection Program, appropriate filtration for effluent air shall be provided.

1. Approved exhaust ventilation means a hood, glovebox, or local exhaust ventilation that is:

(1) Registered with the Radiation Protection Program, and

(2) Approved for adequacy of ventilation by the Industrial Hygiene Program of the MIT Environmental Medical Service.

2. All registered and approved hoods, glove boxes, and local exhaust systems are so designated by printed labels that are attached to the ventilation units by the Industrial Hygiene Program.

6. When hand or clothing contamination is probable, protective gloves and a lab coat shall be worn during operations involving the handling of radioactive materials.

7. After handling unsealed radioactive material, hands shall be washed before

leaving the laboratory, and exposed skin, hair, and clothing shall be surveyed for contamination. The Radiation Protection Program shall be notified immediately if, after decontamination, residual contamination of skin, hair, or personal clothing is detected.

8. Objects and equipment that may have been contaminated with radioactive material shall be surveyed for exterior surface contamination prior to their removal from a laboratory. If surface contamination is detected, the contaminated object shall not be removed from the laboratory without the authorization of the Radiation Protection Program.

9. The Radiation Protection Program shall be notified immediately if any of the following circumstances is known or suspected:

    1. An accident/spill of radioactive material has occurred.

    2. Exposure to inhalation, ingestion, or injection of radioactive material.

    3. Accidental release of radioactive material to laboratory atmosphere, surfaces, drains, or ventilation system.

13. Emergency Procedures

1. In the event of external exposure in excess of the values listed in Appendix 1, or accidental release of radioactive material, the Radiation Protection Program must be notified immediately using the notification procedures of Appendix 4.

2. Emergency procedures to be followed in the event of a radiation contamination accident are specified in Appendix 4 for the following situations:

    1. Serious injury with contamination.
    2. Minor injury with contamination.
    3. Contamination incident without injury.

Appendix 1

Occupational/Nonoccupational Dose Limits

MIT Annual Limits for Radiation Dose

Total Effective Dose Equivalent[1]	5000 mrem
Skin and Extremities (Shallow Dose Equivalent)[2]	50000 mrem
Lens of the Eye	15000 mrem
Declared Pregnant Worker[3]	500 mrem
Minors	500 mrem
Ancillary Personnel/General Public	100 mrem

Notes:

[1] Total Effective Dose Equivalent means the sum of the deep dose equivalent for external exposures and the Committed Effective Dose Equivalent for internal exposures.

[2] Shallow Dose Equivalent which applies to the external exposure of the skin or an extremity, is taken as the dose equivalent at a tissue depth of 0.007 centimeter averaged over an area of 1 square centimeter.

[3] Declared Pregnant Worker dose equivalent limit applies to the time of the entire pregnancy. The RPP requires all pregnant workers who wish to declare their pregnancy to follow the MIT Radiation Protection Committee *Policy Regarding Pregnant Employees and Staff Who Are Potentially Exposed to Ionizing Radiation*.

Appendix 2

MIT Procedure for Procurement of Radioactive Material

I. Procedures for obtaining MIT Authorization to Possess and Use Radioactive Material

A. Complete the form entitled "Application for Authorization to Possess and Use Radioactive Material" and forward a type-written copy to the Radiation Protection Program.

B. When the application has been reviewed and approved, a copy containing the designated Authorization Number will be returned to the Project Supervisor.

C. If any changes are to be made to the information supplied in Section I of an approved authorization application, the Project Supervisor should apply in writing for an amendment. Amendment requests should be sent to the Radiation Protection Program.

II. Procedures for Procuring Radioactive Material

A. Procurement from a Commercial Supplier

1. Prepare and forward the purchase requisition in the usual way, but include on the requisition the words "Radioactive Material", and your Project's Authorization Number (see I.B. above).

2. If a supplier's catalogue number is used to designate the material wanted, also specify on the requisition the radionuclide and the amount of activity.

3. For the radioactive material to be ordered, provide an accurate activity level for the radionuclide currently in the project's inventory.

B. Procurement from the MIT Reactor

Contact the Reactor Business Office to obtain irradiation request forms and information.

C. Procurement or Transfer from Non-Commercial Supplier (labs, institution, hospitals, etc.)

1. Notify the Radiation Protection Program of anticipated receipt of any radioactive material.

2. Specify to supplier to ship all such radioactive material to the Radiation Protection Program.

3. Projects will immediately notify the RPP of any incoming radioactive shipments that have been transported directly to the laboratory.

Appendix 3

Laboratory Disposal of Radioactive Waste

In order to comply with 105 CMR 120, MIT must maintain control of the amounts of radioactivity discharged into the sewerage system, or released to the atmosphere, so that both the required limits on concentration and total activity (per day and per year) are not exceeded. The procedures listed below meet MDPH regulations and must be followed for laboratory disposal of radioactive wastes.

A. Disposal into Sewerage System

Radioactive wastes may be discharged into laboratory drains provided that the following conditions are met:

1. The sink or pipe opening into which the material is to be disposed, has been labeled by the RPP as being approved for radioactive waste disposal.

2. The radioactive material is readily soluble or readily dispersible biological material in water. Projects must prove solubility of waste by reference to the CRC Handbook of Chemistry and Physics, the manufacturer's technical data information or material safety data sheet.

3. The average concentration of the material being disposed will not exceed, for each nuclide, ten times the value listed in Appendix B, Table III, of 105 CMR 120. (Concentration values are posted by the RPP on the label that designates that the sink has been approved for waste disposal.)

4. Aqueous wastes contaminated with short-lived radioactive material (i.e., ^{32}P) in concentrations that exceed item 3 above will be held for radioactive decay to the allowable concentrations for sink disposal.

5. A record shall be kept of the amount of each nuclide disposed into the laboratory drains, using the forms posted by the RPP at each approved sink. The record forms are collected periodically by the RPO.

6. Unless otherwise authorized by the RPO, each laboratory area shall discharge into laboratory drains no more than 10 millicuries of total activity per calendar quarter.

7. Unless authorized by the RPO, scintillation solutions containing radioactive material shall not be discharged into laboratory drains.

8. Unless authorized by the RPO, organic liquids containing radioactive material shall not be discharged into laboratory drains.

B. Disposal into Waste Collection Containers

All radioactive waste not discharged into the laboratory drains shall be put into the special collection containers (solid or liquid) supplied by the RPO, according to the following rules:

1. General Rules

   a. All radioactive material waste must be segregated by the half-life of the radionuclides. Specifically, three categories are segregated: ^{32}P waste, waste with half-lives between 20 and 120 days, and wastes with half-lives greater than 120 days.

   b. The total amount of radioactive material put into any container must be controlled so that the radiation level at one foot from the container is less than 2 mrad/hr and the radiation level at contact with any surface of the container is less than 200 mrad/hr.

   c. Material must not be put into the waste collection containers if there is any possibility of a chemical reaction during storage that might cause fire or explosion, or cause the release of chemically toxic or radioactive gases. Solutions must be adjusted to pH 4-10 prior to disposal into a liquid waste container, unless otherwise authorized by the RPO.

   d. Animal tissue or excreta, or biohazardous, carcinogenic, or toxic material shall not be put into a radioactive material waste collection container, unless the procedure has been specifically authorized by the RPO. Special disposal procedures must be arranged with the RPP prior to the start of work that will produce this kind of waste material.

   e. Any biohazardous, carcinogenic, or toxic material contaminated with radioactive material must be rendered harmless prior to disposal as radioactive waste.

   f. A record must be kept of the quantity and kinds of radioactive material disposed into each collection container. A summary record of these disposals must be available to the RPP technician at the time of collection of the container.

   g. When a container is full or its emitted radiation is approaching the limits specified in item 1.b., contact the Radioactive Waste Management Program (ext. 3-3674) for waste removal.

2. Specific Rules for Disposal into "Solid Radioactive Waste" Collection Containers:

   a. Do not put liquids into a collection container designated for solid waste.

   b. Put powdered material into a metal or plastic container that is sealed prior to disposal.

   c. Unless otherwise authorized by the RPO, do not put more than 25 pounds of material into a collection container.

   d. Unless otherwise authorized by the RPO, do not put objects into a collection container that individually weigh more than 5 pounds.

   e. Hypodermic needles and other sharp objects are segregated by half-life and

placed in RPP provided shatterproof, protective containers. Hypodermic needles should be capped.

f. Special one-gallon solid containers will be installed for projects generating volatile solid waste (e.g., ^{125}I iodinations). These containers will be stored in approved fume hoods. Projects generating such wastes should call the RPP to arrange for set up of these containers.

3. Specific Rules for Disposal Into "Liquid Radioactive Waste" Collection Containers:

a. Do not put solid objects, such as test tubes and bottles into a liquid waste collection container.

b. Pour liquid radioactive wastes (organic and aqueous) into one gallon containers specifically designated for the collection of such solutions.

c. Do not combine aqueous and organic waste in the same container.

4. Specific Rules for Disposal into "Liquid Scintillation Vial" Collection Containers:

a. Scintillation fluids containing ^{3}H and ^{14}C in quantities less than or equal to 0.05 μCi/gram of material will be disposed of in 30 gallon drums clearly marked for their disposal.

b. Scintillation fluids containing ^{32}P will be disposed of in 30 gallon drums clearly marked for their disposal ("^{32}P Liquid Scintillation Vials Only").

c. Scintillation fluids containing any other radionuclide beside those in a. and b. above will be disposed of in appropriate containers provided by the RPO.

5. Specific Rules for Disposal of Animal Carcasses and Tissues:

a. Radioactive animal carcasses and tissues shall be wrapped in polyethylene bags or plastic backed absorbent paper, sealed, labeled, and stored for disposal in a freezer designated by the RPO.

b. The project will attach a completed "Radioactive Material Certification Tag" to all animal carcass packages. The RPP provides the tags.

6. The RPP must be notified prior to the start of work that will produce radioactive waste material not covered by the above regulations.

C. Release of Radioactive Material into Ventilation Exhaust Systems

1. Unless otherwise authorized by the RPP the 24 hour average concentration of radioactive material entering the duct system of each laboratory must not exceed the limits of Appendix B, Table II, Column 1 of 105 CMR 120.

2. The RPP must be notified immediately if there is a release into the environs of airborne

radioactive material in concentrations which, if averaged over a period of 24 hours, would exceed the limits specified for such material in Appendix B, Table II, Column 1, 105 CMR 120.

3. Determinations of the average concentration of radioactive material shall be made with respect to the point where the material leaves the exhaust duct. Concentrations may not be averaged over a period longer than one day, without prior authorization of the RPO.

Appendix 4
Emergency Procedures

Minor Radiation Spill

- Isolate the spill area and guard against re-entry. Alert others in the immediate area that the spill has occurred. Assemble all potentially contaminated persons and monitor them before allowing them to leave the area. Carefully monitor persons' shoes.
- **During work hours, call the Radiation Protection Program at 3-2180. After hours or on weekends, call Campus Police at 100.**
- Remove significantly contaminated clothing and begin decontamination of any exposed skin. Continue to wash exposed skin until all contamination is removed or no further reduction in contamination levels is achieved.
- Remain available at the spill site until contacted by RPO. Spreading of radioactivity beyond the spill area can easily occur by the movement of personnel through the affected area. This will greatly increase decontamination time and effort. Isolation of the spill area and the control of laboratory personnel is very important. Monitoring personnel for contamination is also very important in reducing the spread of radioactivity and minimizing total dose to affected individuals.
- Small localized spills with no spread of contamination may be cleaned by lab personnel responsible for the spill. The clean-up of larger spills with spread of radioactivity needs to be supervised by RPO. All spills must be reported to allow RPP the opportunity to independently monitor the area.

Radiation Spill Involving Volatile Radioactive materials

S **For a release of powered, volatile, or gaseous activity, immediately evacuate lab personnel, assemble outside the laboratory, and stay in this location to prevent any spread of contamination. Isolate the room and prevent re-entry.**

Major Radiation Spill or Injured Contaminated Personnel

- **Attend to contaminated or injured persons and remove them from the spill area/exposure.**
- **Provide necessary first aid to injured persons.**
- **Call Campus Police at 100 and report the location of the spill and the extent of the injuries. State your name, phone number, the fact that radioactivity is involved, and the location where someone is seriously injured**
- **Assemble potentially contaminated personnel in one location of the laboratory and carefully monitor contamination levels. Carefully monitor persons' shoes.**
- **Remove significantly contaminated clothing and begin decontamination of any exposed skin. Continue to wash exposed skin until all contamination is removed or no further reduction in contamination levels is achieved.**
  Isolate the spill area and guard against re-entry.
- **During work hours, call the Radiation Protection Program at 3-2180.**
  Remain available at the spill site until contacted by RPO. RPP will supervise and assist in the spill clean-up and decontamination.

Appendix 5

Reference List of Radionuclides

Quantities which require labeling

Radionuclide	105 CMR Appendix C Value
Calcium-45	100 μCi
Carbon-14	100 μCi
Chlorine-36	10 μCi
Chromium-51	1000 μCi
Cobalt-60	1 μCi
Hydrogen-3	1000 μCi
Iodine-125	1 μCi
Iodine-131	1 μCi
Iron-59	10 μCi
Phosphorous-32	10 μCi
Phosphorous-33	100 μCi
Potassium-42	1000 μCi
Rubidium-86	100 μCi
Sodium-22	10 μCi
Sulphur-35	100 μCi
Technetium-99	100 μCi
Zinc-65	10 μCi

Appendix 6

Glossary of Terms

Radiation	**Energy transmitted as electromagnetic waves or particles from a source.**
Ionizing Radiation	**Any electromagnetic or particulate radiation capable of producing charged particles (ions), directly or indirectly, in its passage through matter: Alpha particles, beta particles, neutrons, gamma rays, x-rays, high speed electrons, high speed protons, and other particles capable of producing ions.**
Alpha particle (α)	**A charged particle emitted from the nucleus of an atom having a mass and charge approximately equal in magnitude of a helium nucleus - LOW penetration ability.**
Beta particle (ß)	**Charged particle emitted from the nucleus of an atom, with a mass and charge equal to that of an electron - MODERATE penetration ability.**
Gamma Ray (γ)	**Short wavelength electromagnetic radiation of nuclear origin. γ rays are VERY penetrating.**
X-ray (χ)	**Short wavelength electromagnetic radiation of extranuclear origin. X rays are VERY penetrating.**
Radioactivity	**The property of certain nuclides of spontaneously emitting particles or gamma radiations or of emitting x radiations following orbital electron capture.**
Curie (Ci)	**Special unit of activity equal to 3.7×10^{10} nuclear transformations (disintegrations) per second (2.22×10^{12} disintegrations per minute). Commonly used quantities:** **millicurie (mCi) - one thousandth of a curie, 2.22×10^{9} dpm** **microcurie (μCi) - one millionth of a curie, 2.22×10^{6} dpm**
Becquerel (Be)	**S.I. unit of activity defined as one atomic transformation (disintegration) per second. 1 Bq = 1 d/s 1 Ci = 3.7×10^{10} Bq.**
Half-life ($T_{1/2}$)	**Time required for a radioactive substance to lose 50% of its activity by decay. Each radionuclide has a unique half-life, e.g. ^{32}P - 14 days.**
Exposure	**A measure of the ionization produced in air by x or gamma radiation.**
Roentgen (R)	**The unit of exposure. One roentgen equals 2.58×10^{-4} coulombs per kilogram of air at STP.**
Absorbed Dose	**The energy imparted to matter by ionizing radiation per unit mass or irradiated material at the place of interest.**

Rad — **The unit of dose (Radiation Absorbed Dose). One rad equals 100 ergs per gram, or 0.01 Joules/kg, of absorbing material.**

Gray (Gy) — **S.I. unit of absorbed dose equal to 100 rad or 1 Joule/kg.**

Dose Equivalent — **A quantity used in radiation protection. It expresses all radiation on a common scale for calculating the effective absorbed dose. It is the product of the absorbed dose in rads and certain modifying or quality factors.**

Rem — **The unit of dose equivalent. The numerical dose equivalent in rems is numerically equivalent to the absorbed dose in rads multiplied by the quality factor, the distribution factor, and any other modifying factors.**

Sievert (Sv) — **S.I. unit of dose equivalent equal to 100 rem.**

Quality Factor — **Modifying factor used to derive dose equivalent from absorbed dose.**

Type of Radiation	Quality Factor
x, γ, and β radiations	1
neutrons	10
α particles	20

Annual Limit on Intake (ALI) — **The amount of radioactive material taken into the body of an adult worker by inhalation or ingestion in a year that would result in a committed effective dose equivalent of 5 rem or a committed dose equivalent of 50 rem to any individual organ or tissue.**

Bremsstrahlung — **Secondary photon radiation produced by the deceleration of charged particles through matter.**

Contamination — **Radioactive material where it is not wanted.**

Derived Air Concentration — **The concentration of a given radionuclide in air which, if inhaled at a rate of 1.2 m^3 of air per hour, results in an intake of one ALI.**

External Dose — **Radiation dose absorbed in human tissues from exposure to radiation sources outside the body.**

Internal Dose — **Radiation dose absorbed in human tissues from exposure to radiation sources that have entered the body thorough inhalation, ingestion or through skin transport.**

Appendix 7

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

ALARA PROGRAM

1. Management Commitment

a. **The management of this teaching and research facility are committed to the program described herein for keeping individual and collective doses as low as is reasonably achievable (ALARA). In accord with this commitment, we hereby describe an administrative organization for radiation protection and will develop the necessary written policies, procedures, and instructions to foster the ALARA concept within MIT. The organization will include a Radiation Protection Committee (RPC) and a Radiation Protection Officer (RPO).**

b. **We will perform a formal annual review of the radiation protection program, including ALARA considerations. This will include reviews of operating procedures, past dose records, inspections, laboratory audits, etc., and consultations with the radiation protection staff.**

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

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

e. **The RPC will meet quarterly to review the MIT ALARA program with a formal written review on an annual basis.**

2. Radiation Protection Committee

a. Review of Proposed Users and Uses

(1) The RPC will thoroughly review the qualifications of each project supervisor with respect to the types and quantities of byproduct materials and methods of use for which application (RP-01) has been made to the RPP to ensure that the applicant will be able to take appropriate measures to maintain exposure ALARA. The RPC will meet quarterly to review applications.

(2) When considering a new use of significant quantities of byproduct material, the RPC will review the past efforts of the applicant at maintaining exposures ALARA.

(3) The RPC will ensure that the users justify their procedures and that individual and collective doses will be ALARA. The RPC will specify conditions of approval which must be followed to maintain exposures ALARA.

b. Delegation of Authority

(1) The RPC will delegate authority to the RPP for enforcement of the ALARA concept.

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

c. Review of ALARA Program

(1) The RPC encourages all users together with the staff of the Radiation Protection Program to review current procedures and develop new procedures as appropriate to implement the ALARA concept.

(2) The RPC will perform a quarterly review of occupational radiation exposures with particular attention to instances in which the investigational levels in Table 1 are exceeded. The principle purpose of this review is to assess trends in occupational exposure as an index of the ALARA program quality and to decide if action is warranted when investigational levels are exceeded.

(3) The RPC will evaluate MIT's overall efforts for maintaining doses ALARA on an annual basis. This review will include the efforts of the RPO, project supervisors, and radiation workers as well as those of management. The RPP will present an annual summary of exposure levels to the RPC.

Table 1
Investigational Levels

	(mrem/calendar quarter) Level I	Level II
Whole body; head and trunk; active blood-forming organs; lens of eyes; or gonads	**125**	**375**
Hands and forearms; feet and ankles, skin of the whole body	**1250**	**3750**

3. Radiation Protection Officer

a. Annual and Quarterly Review

(1) Annual review of the Radiation Protection Program.

The RSO will perform an annual review of the radiation protection program for adherence to ALARA concepts. The review will be reported to the RPC.

(2) Quarterly review of occupational exposures.

The RPP will review at least quarterly the external radiation doses of authorized users and workers to determine that their doses are ALARA in accordance with the provisions of Section 6 of this program and will prepare a summary report for the RPC.

(3) Quarterly review of records of radiation surveys.

The RPP will review radiation surveys in restricted, controlled and uncontrolled and areas to determine that dose rates and amounts of contamination were at ALARA levels during the previous quarter and will report for the RPC.

b. Education Responsibilities for ALARA Program

(1) The Radiation Protection Program staff schedule radiation worker training seminars and educational sessions to inform workers of ALARA program efforts. Also, the RPP staff attend MIT departmental safety meetings on a routine basis and several times per year give presentations regarding radiation protection matters including ALARA concerns.

(2) The RPP will ensure that project supervisors, radiation workers, and ancillary personnel who may be exposed to radiation will be instructed in the ALARA philosophy and informed that management, the RPC, and the RPP are committed to implementing the ALARA concept.

c. Cooperative Efforts for Development of ALARA Procedures

Project supervisors and radiation workers will be given opportunities to participate in formulating the procedures that they will be required to follow.

(1) The RPP will work closely with all projects and workers in order to develop ALARA procedures for working with radioactive materials.

(2) The RPP will evaluate the suggestions of individual radiation workers and ancillary workers for improving health physics and ALARA practices and will encourage the use of those suggestions as formalized procedures.

d. Reviewing Instances of Deviation from Good ALARA Practices

The RPP will investigate all known instances of deviation from good ALARA practices and, if possible, will determine the causes. When the cause is known, the RPP will implement changes in the program to maintain doses ALARA. All deviations from good ALARA practices will be reported to the RPC at the next scheduled quarterly meeting.

4. Project Supervisors

a. General Requirements

(1) The project supervisor will explain the ALARA concept and the need to maintain exposures ALARA to all supervised radiation workers.

(2) The project supervisor will ensure that supervised individuals who are subject to occupational radiation exposures attend the Radiation Protection Program mandatory radiation worker training seminar and are further trained in specific handling procedures and good health physics practices in the laboratory to keep exposures ALARA.

b. New Methods of Use Involving Potential Radiation Doses

(1) Project supervisors will consult with the RPP during the planning stages for experiments involving significant quantities of radioactive materials for new uses. These proposed uses will then be forwarded to the RPC for review and approval.

(2) The project supervisor will review each planned use of radioactive materials to ensure that doses will be kept ALARA. Trial or dry runs using non radioactive material or reduced quantities will be required prior to the handling of significant quantities of material for the first time.

5. Individuals Who Receive Occupational Radiation Doses

a. Radiation workers and ancillary personnel will be instructed in the ALARA concept and its relationship to work procedures and work conditions.

b. Radiation workers will be instructed in resources available if they feel that ALARA is

not being promoted on the job.

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

MIT hereby establishes investigational levels for occupational external radiation doses which, when exceeded, will initiate review or investigation by the RPC and/or the RPO. The investigational levels that we have adopted are listed in Table 1. These levels apply to the exposure of individual workers.

The RPP will review and record on Form NRC-5, "Current Occupational External Radiation Exposures," or an equivalent form (e.g., R.S. Landauer dosimeter processors's report) results of personnel monitoring as required by 120.226 of 105 CMR. The following actions will be taken at the investigational levels as stated in Table 1:

a. Personnel Dose Less Than Investigational Level I.

Except when deemed appropriate by the RPO, no further action will be taken in those cases where an individual's dose is less than Table 1 values for the Investigation Level I.

b. Personnel Dose Equal To or Greater Than Investigational Level I but Less Than Investigational Level II.

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

c. Personnel Dose Equal To or Greater Than Investigational Level II.

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

d. Reestablishment of investigational levels to levels above those listed in Table 1.

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

The RPC will review the justification for and must approve or disapprove all revisions of investigational levels prior to these new levels being put into practice.

7. Signature of Certifying Official

I hereby certify that the Massachusetts Institute of Technology has implemented the ALARA Program set forth above.

(Signature)

Name (print or type) **Title**

Appendix 8

RADIATION INFORMATION SHEET

Information

Most radionuclides used in the laboratories at MIT and the Whitehead Institute are beta and/or X and gamma ray emitters. The following is a list of the most commonly used radionuclides:

Isotope	Major Radiations	Intensities (KeV)	Half Life	Liquid Waste Sink Disposal as 10 times 105 CMR 120 Appendix B, Table III	Recommended Detection Method
^{3}H	Beta	18.6	12.6 yrs	100 μCi/l	LSC
^{14}C	Beta	156	5730 yrs	3.0 μCi/l	GM (pancake), LSC
^{35}S	Beta	167	88 days	10 μCi/l	GM (pancake), LSC
^{32}P	Beta	1710	14 days	0.9 μCi/l	GM
^{33}P	Beta	249	25 days	8.0 μCi/l	GM (pancake)
^{36}Cl	Beta	714	3.05×10^{5} yrs	2.0 μCi/l	GM
^{45}Ca	Beta	252	165 days	2.0 μCi/l	GM (pancake)
^{51}Cr	Gamma	320	27.8 days	50 μCi/l	GM
^{59}Fe	Beta Gamma	273, 466 1099, 1292	45.6 days	1.0 μCi/l	GM
^{86}Rb	Beta Gamma	1780 1078	18.6 days	0.7 μCi/l	GM
^{99}Tc	Beta	293	2.12×10^{5} yrs	6.0 μCi/l	GM (pancake)
^{125}I	X,Gamma	28,31	60 days	0.2 μCi/l	NaI
^{131}I	Beta Gamma	606 364	8.05 days	0.1 μCi/l	GM

GM = Geiger Mueller detector, LSC = Liquid Scintillation Counter, NaI = Sodium Iodide detector

Note: Any radioactive waste that may be discharged into the laboratory drains (as listed above) must meet the conditions in Appendix 3 of the MIT Required Procedures for Radiation Protection. The total activity disposed in each laboratory must not exceed the following quantities: ^{3}H = 25 mCi per calendar quarter and ^{14}C = 10 mCi per calendar quarter. All other radionuclides: 10 mCi total per calendar quarter.

Personnel External Exposure Control

The three basic methods used to control external radiation exposure are:

TIME	□	**Minimize time**
DISTANCE	□	**Maximize distance**
SHIELDING	□	**Use proper shielding**

Any one method or any combination of the three methods should be used to keep personal exposure As Low As Reasonably Achievable (ALARA).

The Inverse Square Law

If one doubles the distance, one reduces the absorbed dose or absorbed dose rate by a factor of four due to the divergence of photons from a point. Formula: $R_1D_1^2 = R_2D_2^2$

Example: For an exposure rate of 1000 mR/hr at 1 cm, what is the exposure rate at 10 cm?

$$R_2 = (R_1D_1^2) / D_2^2$$
$$R_2 = [(1000 \text{ mR/hr})(1 \text{ cm})^2\}] / (10 \text{ cm})^2$$
$$R_2 = 1000 / 100 \text{ mR/hr}$$
$$R_2 = 10 \text{ mR/hr @ 10 cm}$$

RULES OF THUMB

1. **It requires a beta particle of at least 70 keV to penetrate the protective layer of the skin (0.07 mm thick).**

2. **The average energy of a beta particle is 1/3 times the maximum energy: $E_{avg} = 1/3 (E_{max})$**

3. **The range of a beta particle in air is approximately 12 feet per MeV; for example, a 1.7 MeV (E_{max}) beta particle has a range of about 20 feet in air.**

4. **The intensity of Bremsstrahlung (braking) radiation increases as the energy of the beta particle and the atomic number of the absorbing material increases. Thus, a shield consisting of low atomic number material should be used for ^{32}P.**

5. **When beta particles of 1 to 2 MeV pass through light materials such as water, plexiglass, or glass, less than 1% of their energy is dissipated as Bremsstrahlung.**

6. **The beta particles from the decay of ^{32}P are stopped in 1/4 inch of plexiglass.**

7. **Lead is an excellent shield for low energy X and gamma ray emitters. The thickness of lead needed is determined by the intensity and energy of the X and gamma rays.**

8. **The half value layer (HVL) is the thickness of an absorber (e.g., lead) that will reduce the X and gamma ray intensity by a factor of 2.**

RULES FOR WORKING WITH RADIOIODINE

1. **All persons who handle ≥ 500μCi of unbound radioiodine are required to have a baseline thyroid measurement prior to beginning such work. Call the RPP secretary at 3-2180 for appointment.**

2. **All purchase orders for radioiodine must specify the end user(s) name. Orders not in compliance will not be approved.**

3. **All persons handling ≥ 500μCi unbound radioiodine, including persons involved in the iodination procedure are required to report to the RPP for a thyroid burden measurement within 5 working days after using the material. Call the RPP secretary at 3-2180 for appointment. Persons not in compliance will be restricted from future use of radioiodine.**

4. **Iodinations will be performed in the charcoal filtered hood in room*. All users must sign the logbook located in that laboratory. *E17-329, 68-284, 6-017, or 56-354**

STYROFOAM PACKAGE RECYCLING PROCEDURES

1. **Inspect the Styrofoam container to insure that there has been no damage in transit.**

2. **Remove all hazardous material from the container (e.g. dry ice).**

3. **Monitor the external and internal surfaces of the container with the Geiger Mueller detector. Contaminated containers cannot be recycled.**

4. **Tape the top and bottom together as a unit. Please make sure you securely tape them together.**

5. **Complete the return address information on the attached return label. Include your laboratory room number in the return address.**

6. **NOTE: Please do not return the cardboard box to the recycling locations. Deliver the package to one of the following areas on campus:**

Recycling Location	Recycling Coordinator
Room E25-169 Room 68-018 Room E17-121	(3-4317) (3-4711) (3-6403)

To ensure compliance with federal regulations for mailing these packages, a wipe test of the container must be performed prior to the package leaving MIT. The success of this program depends upon us working together. If you have any questions, please call the Radiation Protection Program (3-2180).

Appendix 9

Risks From Occupational Radiation Exposure

U.S. NUCLEAR REGULATORY COMMISSION

Revision 1
February 1996

REGULATORY GUIDE

OFFICE OF NUCLEAR REGULATORY RESEARCH

REGULATORY GUIDE 8.29

(Draft was issued as DG-8012)

INSTRUCTION CONCERNING RISKS FROM OCCUPATIONAL RADIATION EXPOSURE

A. INTRODUCTION

Section 19.12 of 10 CFR Part 19, "Notices, Instructions and Reports to Workers: Inspection and Investigations," requires that all individuals who in the course of their employment are likely to receive in a year an occupational dose in excess of 100 mrem (1 mSv) be instructed in the health protection issues associated with exposure to radioactive materials or radiation. Section 20.1206 of 10 CFR Part 20, "Standards for Protection Against Radiation," requires that before a planned special exposure occurs the individuals involved are, among other things, to be informed of the estimated doses and associated risks.

This regulatory guide describes the information that should be provided to workers by licensees about health risks from occupational exposure. This revision conforms to the revision of 10 CFR Part 20 that became effective on June 20, 1991, to be implemented by licensees no later than January 1, 1994. The revision of 10 CFR Part 20 establishes new dose limits based on the effective dose equivalent (EDE), requires the summing of internal and external dose, establishes a requirement that licensees use procedures and engineering controls to the extent practicable to achieve occupational doses and doses to members of the public that are as low as is reasonably achievable (ALARA), provides for planned special exposures, establishes a dose limit for the embryo/fetus of an occupationally exposed declared pregnant woman, and explicitly states that Part 20 is not to be construed as limiting action that may be necessary to protect health and safety during emergencies.

Any information collection activities mentioned in this regulatory guide are contained as requirements in 10 CFR Part 19 or 10 CFR Part 20. These regulations provide the regulatory bases for this guide. The information collection requirements in 10 CFR Parts 19 and 20 have been cleared under OMB Clearance Nos. 3150-0044 and 3150-0014, respectively.

B. DISCUSSION

It is important to qualify the material presented in this guide with the following considerations.

The coefficient used in this guide for occupational radiation risk estimates, 4×10^{-4} health effects per rem, is based on data obtained at much higher doses and dose rates than those encountered by workers. The risk coefficient obtained at high doses and dose rates was reduced to account for the reduced effectiveness of lower doses and dose rates in producing the stochastic effects observed in studies of exposed humans.

The assumption of a linear extrapolation from the lowest doses at which effects are observable down to

the occupational range has considerable uncertainty. The report of the Committee on the Biological Effects of Ionizing Radiation (Ref. 1) states that

> "... departure from linearity cannot be excluded at low doses below the range of observation. Such departures could be in the direction of either an increased or decreased risk. Moreover, epidemiologic data cannot rigorously exclude the existence of a threshold in the 100 mrem dose range. Thus, the possibility that there may be no risk from exposures comparable to external natural background radiation cannot be ruled out. At such low doses and dose rates, it must be acknowledged that the lower limit of the range of uncertainty in the risk estimates extends to zero."

The issue of beneficial effects from low doses, or hormesis, in cellular systems is addressed by the United Nations Scientific Committee on the Effects of Atomic Radiation (Ref. 2). UNSCEAR states that "... it would be premature to conclude that cellular adaptive responses could convey possible beneficial effects to the organism that would outweigh the detrimental effects of exposures to low doses of low-LET radiation."

In the absence of scientific certainty regarding the relationship between low doses and health effects, and as a conservative assumption for radiation protection purposes, the scientific community generally assumes that any exposure to ionizing radiation can cause biological effects that may be harmful to the exposed person and that the magnitude or probability of these effects is directly proportional to the dose. These effects may be classified into three categories:

> *Somatic Effects:* Physical effects occurring in the exposed person. These effects may be observable after a large or acute dose (e.g., 100 rems[1] (1 Sv) or more to the whole body in a few hours); or they may be effects such as cancer that may occur years after exposure to radiation.
>
> *Genetic Effects:* Abnormalities that may occur in the future children of exposed individuals and in subsequent generations (genetic effects exceeding normal incidence have not been observed in any of the studies of human populations).
>
> *Teratogenic Effects:* Effects such as cancer or congenital malformation that may be observed in children who were exposed during the fetal and embryonic stages of development (these effects have been observed from high, i.e., above 20 rems (0.2 Sv), acute exposures).

The normal incidence of effects from natural and manmade causes is significant. For example, approximately 20% of people die from various forms of cancer whether or not they ever receive occupational exposure to radiation. To avoid increasing the incidence of such biological effects, regulatory controls are imposed on occupational doses to adults and minors and on doses to the embryo/fetus from occupational exposures of declared pregnant women.

Radiation protection training for workers who are occupationally exposed to ionizing radiation is an essential component of any program designed to ensure compliance with NRC regulations. A clear understanding of what is presently known about the biological risks associated with exposure to radiation will result in more effective radiation protection training and should generate more interest on the part of the workers in complying with radiation protection standards. In addition, pregnant women and other occupationally exposed workers should have available to them relevant information on radiation risks to enable them to make informed decisions regarding the acceptance of these risks. It is intended that workers who receive this instruction will develop respect for the risks involved, rather than excessive fear or indifference.

C. REGULATORY POSITION

Instruction to workers performed in compliance with 10 CFR 19.12 should be given prior to occupational exposure and periodically thereafter. The frequency of retraining might range from annually for licensees with complex operations such as nuclear power plants, to every three years for licensees who possess, for example, only low-activity sealed sources. If a worker is to participate in a planned special exposure, the worker should be informed of the associated risks in compliance with 10 CFR 20.1206.

In providing instruction concerning health protection problems associated with exposure to radiation, all occupationally exposed workers and their supervisors should be given specific instruction on the risk of biological effects resulting from exposure to radiation. The extent of these instructions should be commensurate with the radiological risks present in the workplace.

The instruction should be presented orally, in printed form, or in any other effective communication media to workers and supervisors. The appendix to this guide provides useful information for demonstrating compliance with the training requirements in 10 CFR Parts 19 and 20. Individuals should be given an opportunity to discuss the information and to ask questions. Testing is recommended, and each trainee should be asked to acknowledge in writing that the instruction has been received and understood.

[1] In the International System of Units (SI), the rem is replaced by the sievert; 100 rems is equal to 1 sievert (Sv).

D. IMPLEMENTATION

The purpose of this section is to provide information to applicants and licensees regarding the NRC staff's plans for using this regulatory guide.

Except in those cases in which an applicant or licensee proposes acceptable alternative methods for complying with specified portions of the Commission's regulations, the guidance and instructional materials in this guide will be used in the evaluation of applications for new licenses, license renewals, and license amendments and for evaluating compliance with 10 CFR 19.12 and 10 CFR Part 20.

REFERENCES

1. National Research Council, *Health Effects of Exposure to Low Levels of Ionizing Radiation*, Report of the Committee on the Biological Effects of Ionizing Radiation (BEIR V), National Academy Press, Washington, DC, 1990.
2. United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), *Sources and Effects of Ionizing Radiation*, United Nations, New York, 1993.

APPENDIX

INSTRUCTION CONCERNING RISKS FROM OCCUPATIONAL RADIATION EXPOSURE

This instructional material is intended to provide the user with the best available information about the health risks from occupational exposure to ionizing radiation. Ionizing radiation consists of energy or small particles, such as gamma rays and beta and alpha particles, emitted from radioactive materials, which can cause chemical or physical damage when they deposit energy in living tissue. A question and answer format is used. Many of the questions or subjects were developed by the NRC staff in consultation with workers, union representatives, and licensee representatives experienced in radiation protection training.

This Revision 1 to Regulatory Guide 8.29 updates the material in the original guide on biological effects and risks and on typical occupational exposure. Additionally, it conforms to the revised 10 CFR Part 20, "Standards for Protection Against Radiation," which was required to be implemented by licensees no later than January 1, 1994. The information in this appendix is intended to help develop respect by workers for the risks associated with radiation, rather than unjustified fear or lack of concern. Additional guidance concerning other topics in radiation protection training is provided in other NRC regulatory guides.

1. What is meant by health risk?

A health risk is generally thought of as something that may endanger health. Scientists consider health risk to be the statistical probability or mathematical chance that personal injury, illness, or death may result from some action. Most people do not think about health risks in terms of mathematics. Instead, most of us consider the health risk of a particular action in terms of whether we believe that particular action will, or will not, cause us some harm. The intent of this appendix is to provide estimates of, and explain the bases for, the risk of injury, illness, or death from occupational radiation exposure. Risk can be quantified in terms of the probability of a health effect per unit of dose received.

When x-rays, gamma rays, and ionizing particles interact with living materials such as our bodies, they may deposit enough energy to cause biological damage. Radiation can cause several different types of events such as the very small physical displacement of molecules, changing a molecule to a different form, or ionization, which is the removal of electrons from atoms and molecules. When the quantity of radiation energy deposited in living tissue is high enough, biological damage can occur as a result of chemical bonds being broken and cells being damaged or killed. These effects can result in observable clinical symptoms.

The basic unit for measuring absorbed radiation is the rad. One rad (0.01 gray in the International System of units) equals the absorption of 100 ergs (a small but measurable amount of energy) in a gram of material such as tissue exposed to radiation. To reflect biological risk, rads must be converted to rems. The new international unit is the sievert (100 rems = 1 Sv). This conversion accounts for the differences in the effectiveness of different types of radiation in causing damage. The rem is used to estimate biological risk. For beta and gamma radiation, a rem is considered equal to a rad.

2. What are the possible health effects of exposure to radiation?

Health effects from exposure to radiation range from no effect at all to death, including diseases such as leukemia or bone, breast, and lung cancer. Very high (100s of rads), short-term doses of radiation have been known to cause prompt (or early) effects, such as vomiting and diarrhea,[1] skin burns, cataracts, and even death. It is suspected that radiation exposure may be linked to the potential for genetic effects in the children of exposed parents. Also, children who were exposed to high doses (20 or more rads) of radiation prior to birth (as an embryo/fetus) have shown an increased risk of mental retardation and other congenital malformations. These effects (with the exception of genetic effects) have been observed in various studies of medical radiologists, uranium miners, radium workers, radiotherapy patients, and the people exposed to radiation from atomic bombs dropped on Japan. In addition, radiation effects studies with laboratory animals, in which the animals were given relatively high doses, have provided extensive data on radiation-induced health effects, including genetic effects.

It is important to note that these kinds of health effects result from high doses, compared to occupational levels, delivered over a relatively short period of time.

Although studies have not shown a consistent cause-and-effect relationship between current levels of occupational radiation exposure and biological effects, it is prudent from a worker protection perspective to assume that some effects may occur.

[1]These symptoms are early indicators of what is referred to as the acute radiation syndrome, caused by high doses delivered over a short time period, which includes damage to the blood-forming organs such as bone marrow, damage to the gastrointestinal system, and, at very high doses, can include damage to the central nervous system.

3. What is meant by early effects and delayed or late effects?

EARLY EFFECTS

Early effects, which are also called immediate or prompt effects, are those that occur shortly after a large exposure that is delivered within hours to a few days. They are observable after receiving a very large dose in a short period of time, for example, 300 rads (3 Gy) received within a few minutes to a few days. Early effects are not caused at the levels of radiation exposure allowed under the NRC's occupational limits.

Early effects occur when the radiation dose is large enough to cause extensive biological damage to cells so that large numbers of cells are killed. For early effects to occur, this radiation dose must be received within a short time period. This type of dose is called an acute dose or acute exposure. The same dose received over a long time period would not cause the same effect. Our body's natural biological processes are constantly repairing damaged cells and replacing dead cells; if the cell damage is spread over time, our body is capable of repairing or replacing some of the damaged cells, reducing the observable adverse conditions.

For example, a dose to the whole body of about 300–500 rads (3–5 Gy), more than 60 times the annual occupational dose limit, if received within a short time period (e.g., a few hours) will cause vomiting and diarrhea within a few hours; loss of hair, fever, and weight loss within a few weeks; and about a 50 percent chance of death if medical treatment is not provided. These effects would not occur if the same dose were accumulated gradually over many weeks or months (Refs. 1 and 2). Thus, one of the justifications for establishing annual dose limits is to ensure that occupational dose is spread out in time.

It is important to distinguish between whole body and partial body exposure. A localized dose to a small volume of the body would not produce the same effect as a whole body dose of the same magnitude. For example, if only the hand were exposed, the effect would mainly be limited to the skin and underlying tissue of the hand. An acute dose of 400 to 600 rads (4–6 Gy) to the hand would cause skin reddening; recovery would occur over the following months and no long-term damage would be expected. An acute dose of this magnitude to the whole body could cause death within a short time without medical treatment. Medical treatment would lessen the magnitude of the effects and the chance of death; however, it would not totally eliminate the effects or the chance of death.

DELAYED EFFECTS

Delayed effects may occur years after exposure. These effects are caused indirectly when the radiation changes parts of the cells in the body, which causes the normal function of the cell to change, for example, normal healthy cells turn into cancer cells. The potential for these delayed health effects is one of the main concerns addressed when setting limits on occupational doses.

A delayed effect of special interest is genetic effects. Genetic effects may occur if there is radiation damage to the cells of the gonads (sperm or eggs). These effects may show up as genetic defects in the children of the exposed individual and succeeding generations. However, if any genetic effects (i.e., effects in addition to the normal expected number) have been caused by radiation, the numbers are too small to have been observed in human populations exposed to radiation. For example, the atomic bomb survivors (from Hiroshima and Nagasaki) have not shown any significant radiation-related increases in genetic defects (Ref. 3). Effects have been observed in animal studies conducted at very high levels of exposure and it is known that radiation can cause changes in the genes in cells of the human body. However, it is believed that by maintaining worker exposures below the NRC limits and consistent with ALARA, a margin of safety is provided such that the risk of genetic effects is almost eliminated.

4. What is the difference between acute and chronic radiation dose?

Acute radiation dose usually refers to a large dose of radiation received in a short period of time. Chronic dose refers to the sum of small doses received repeatedly over long time periods, for example, 20 mrem (or millirem, which is 1-thousandth of a rem) (0.2 mSv) per week every week for several years. It is assumed for radiation protection purposes that any radiation dose, either acute or chronic, may cause delayed effects. However, only large acute doses cause early effects; chronic doses within the occupational dose limits do not cause early effects. Since the NRC limits do not permit large acute doses, concern with occupational radiation risk is primarily focused on controlling chronic exposure for which possible delayed effects, such as cancer, are of concern.

The difference between acute and chronic radiation exposure can be shown by using exposure to the sun's rays as an example. An intense exposure to the sun can result in painful burning, peeling, and growing of new skin. However, repeated short exposures provide time for the skin to be repaired between exposures. Whether exposure to the sun's rays is long term or spread over short periods, some of the injury may not be repaired and may eventually result in skin cancer.

Cataracts are an interesting case because they can be caused by both acute and chronic radiation. A certain threshold level of dose to the lens of the eye is required before there is any observable visual impairment, and the impairment remains after the exposure is stopped. The threshold for cataract development

from acute exposure is an acute dose on the order of 100 rads (1 Gy). Further, a cumulative dose of 800 rads (8 Gy) from protracted exposures over many years to the lens of the eye has been linked to some level of visual impairment (Refs. 1 and 4). These doses exceed the amount that may be accumulated by the lens from normal occupational exposure under the current regulations.

5. What is meant by external and internal exposure?

A worker's occupational dose may be caused by exposure to radiation that originates outside the body, called "external exposure," or by exposure to radiation from radioactive material that has been taken into the body, called "internal exposure." Most NRC-licensed activities involve little, if any, internal exposure. It is the current scientific consensus that a rem of radiation dose has the same biological risk regardless of whether it is from an external or an internal source. The NRC requires that dose from external exposure and dose from internal exposure be added together, if each exceeds 10% of the annual limit, and that the total be within occupational limits. The sum of external and internal dose is called the total effective dose equivalent (TEDE) and is expressed in units of rems (Sv).

Although unlikely, radioactive materials may enter the body through breathing, eating, drinking, or open wounds, or they may be absorbed through the skin. The intake of radioactive materials by workers is generally due to breathing contaminated air. Radioactive materials may be present as fine dust or gases in the workplace atmosphere. The surfaces of equipment and workbenches may be contaminated, and these materials can be resuspended in air during work activities.

If any radioactive material enters the body, the material goes to various organs or is excreted, depending on the biochemistry of the material. Most radioisotopes are excreted from the body in a few days. For example, a fraction of any uranium taken into the body will deposit in the bones, where it remains for a longer time. Uranium is slowly eliminated from the body, mostly by way of the kidneys. Most workers are not exposed to uranium. Radioactive iodine is preferentially deposited in the thyroid gland, which is located in the neck.

To limit risk to specific organs and the total body, an annual limit on intake (ALI) has been established for each radionuclide. When more than one radionuclide is involved, the intake amount of each radionuclide is reduced proportionally. NRC regulations specify the concentrations of radioactive material in the air to which a worker may be exposed for 2,000 working hours in a year. These concentrations are termed the derived air concentrations (DACs). These limits are the total amounts allowed if no external radiation is received. The resulting dose from the internal radiation sources (from breathing air at 1 DAC) is the maximum allowed to an organ or to the worker's whole body.

6. How does radiation cause cancer?

The mechanisms of radiation-induced cancer are not completely understood. When radiation interacts with the cells of our bodies, a number of events can occur. The damaged cells can repair themselves and permanent damage is not caused. The cells can die, much like the large numbers of cells that die every day in our bodies, and be replaced through the normal biological processes. Or a change can occur in the cell's reproductive structure, the cells can mutate and subsequently be repaired without effect, or they can form precancerous cells, which may become cancerous. Radiation is only one of many agents with the potential for causing cancer, and cancer caused by radiation cannot be distinguished from cancer attributable to any other cause.

Radiobiologists have studied the relationship between large doses of radiation and cancer (Refs. 5 and 6). These studies indicate that damage or change to genes in the cell nucleus is the main cause of radiation-induced cancer. This damage may occur directly through the interaction of the ionizing radiation in the cell or indirectly through the actions of chemical products produced by radiation interactions within cells. Cells are able to repair most damage within hours; however, some cells may not be repaired properly. Such misrepaired damage is thought to be the origin of cancer, but misrepair does not always cause cancer. Some cell changes are benign or the cell may die; these changes do not lead to cancer.

Many factors such as age, general health, inherited traits, sex, as well as exposure to other cancer-causing agents such as cigarette smoke can affect susceptibility to the cancer-causing effects of radiation. Many diseases are caused by the interaction of several factors, and these interactions appear to increase the susceptibility to cancer.

7. Who developed radiation risk estimates?

Radiation risk estimates were developed by several national and international scientific organizations over the last 40 years. These organizations include the National Academy of Sciences (which has issued several reports from the Committee on the Biological Effects of Ionizing Radiations, BEIR), the National Council on Radiation Protection and Measurements (NCRP), the International Commission on Radiological Protection (ICRP), and the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR). Each of these organizations continues to review new research findings on radiation health risks.

Several reports from these organizations present new findings on radiation risks based upon revised estimates of radiation dose to survivors of the atomic bombing at Hiroshima and Nagasaki. For example, UNSCEAR published risk estimates in 1988 and 1993 (Refs. 5 and 6). The NCRP also published a report in 1988, "New Dosimetry at Hiroshima and Nagasaki and Its Implications for Risk Estimates" (Ref. 7). In January 1990, the National Academy of Sciences released the fifth report of the BEIR Committee, "Health Effects of Exposure to Low Levels of Ionizing Radiation" (Ref. 4). Each of these publications also provides extensive bibliographies on other published studies concerning radiation health effects for those who may wish to read further on this subject.

8. What are the estimates of the risk of fatal cancer from radiation exposure?

We don't know exactly what the chances are of getting cancer from a low-level radiation dose, primarily because the few effects that may occur cannot be distinguished from normally occurring cancers. However, we can make estimates based on extrapolation from extensive knowledge from scientific research on high dose effects. The estimates of radiation effects at high doses are better known than are those of most chemical carcinogens (Ref. 8).

From currently available data, the NRC has adopted a risk value for an occupational dose of 1 rem (0.01 Sv) Total Effective Dose Equivalent (TEDE) of 4 in 10,000 of developing a fatal cancer, or approximately 1 chance in 2,500 of fatal cancer per rem of TEDE received. The uncertainty associated with this risk estimate does not rule out the possibility of higher risk, or the possibility that the risk may even be zero at low occupational doses and dose rates.

The radiation risk incurred by a worker depends on the amount of dose received. Under the linear model explained above, a worker who receives 5 rems (0.05 Sv) in a year incurs 10 times as much risk as another worker who receives only 0.5 rem (0.005 Sv). Only a very few workers receive doses near 5 rems (0.05 Sv) per year (Ref. 9).

According to the BEIR V report (Ref. 4), approximately one in five adults normally will die from cancer from all possible causes such as smoking, food, alcohol, drugs, air pollutants, natural background radiation, and inherited traits. Thus, in any group of 10,000 workers, we can estimate that about 2,000 (20%) will die from cancer without any occupational radiation exposure.

To explain the significance of these estimates, we will use as an example a group of 10,000 people, each exposed to 1 rem (0.01 Sv) of ionizing radiation. Using the risk factor of 4 effects per 10,000 rem of dose, we estimate that 4 of the 10,000 people might die from delayed cancer because of that 1-rem dose (although the actual number could be more or less than 4) in addition to the 2,000 normal cancer fatalities expected to occur in that group from all other causes. This means that a 1-rem (0.01 Sv) dose may increase an individual worker's chances of dying from cancer from 20 percent to 20.04 percent. If one's lifetime occupational dose is 10 rems, we could raise the estimate to 20.4 percent. A lifetime dose of 100 rems may increase chances of dying from cancer from 20 to 24 percent. The average measurable dose for radiation workers reported to the NRC was 0.31 rem (0.0031 Sv) for 1993 (Ref. 9). Today, very few workers ever accumulate 100 rems (1 Sv) in a working lifetime, and the average career dose of workers at NRC-licensed facilities is 1.5 rems (0.015 Sv), which represents an estimated increase from 20 to about 20.06 percent in the risk of dying from cancer.

It is important to understand the probability factors here. A similar question would be, "If you select one card from a full deck of cards, will you get the ace of spades?" This question cannot be answered with a simple yes or no. The best answer is that your chance is 1 in 52. However, if 1000 people each select one card from full decks, we can predict that about 20 of them will get an ace of spades. Each person will have 1 chance in 52 of drawing the ace of spades, but there is no way we can predict which persons will get that card. The issue is further complicated by the fact that in a drawing by 1000 people, we might get only 15 successes, and in another, perhaps 25 correct cards in 1000 draws. We can say that if you receive a radiation dose, you will have increased your chances of eventually developing cancer. It is assumed that the more radiation exposure you get, the more you increase your chances of cancer.

The normal chance of dying from cancer is about one in five for persons who have not received any occupational radiation dose. The additional chance of developing fatal cancer from an occupational exposure of 1 rem (0.01 Sv) is about the same as the chance of drawing any ace from a full deck of cards three times in a row. The additional chance of dying from cancer from an occupational exposure of 10 rem (0.1 Sv) is about equal to your chance of drawing two aces successively on the first two draws from a full deck of cards.

It is important to realize that these risk numbers are only estimates based on data for people and research animals exposed to high levels of radiation in short periods of time. There is still uncertainty with regard to estimates of radiation risk from low levels of exposure. Many difficulties are involved in designing research studies that can accurately measure the projected small increases in cancer cases that might be caused by low exposures to radiation as compared to the normal rate of cancer.

These estimates are considered by the NRC staff to be the best available for the worker to use to make an informed decision concerning acceptance of the risks associated with exposure to radiation. A worker who decides to accept this risk should try to keep exposure to radiation as low as is reasonably achievable (ALARA) to avoid unnecessary risk.

9. If I receive a radiation dose that is within occupational limits, will it cause me to get cancer?

Probably not. Based on the risk estimates previously discussed, the risk of cancer from doses below the occupational limits is believed to be small. Assessment of the cancer risks that may be associated with low doses of radiation are projected from data available at doses larger than 10 rems (0.1 Sv) (Ref. 3). For radiation protection purposes, these estimates are made using the straight line portion of the linear quadratic model (Curve 2 in Figure 1). We have data on cancer probabilities only for high doses, as shown by the solid line in Figure 1. Only in studies involving radiation doses above occupational limits are there dependable determinations of the risk of cancer, primarily because below the limits the effect is small compared to differences in the normal cancer incidence from year to year and place to place. The ICRP, NCRP, and other standards-setting organizations assume for radiation protection purposes that there is some risk, no matter how small the dose (Curves 1 and 2). Some scientists believe that the risk drops off to zero at some low dose (Curve 3), the threshold effect. The ICRP and NCRP endorse the linear quadratic model as a conservative means of assuring safety (Curve 2).

For regulatory purposes, the NRC uses the straight line portion of Curve 2, which shows the number of effects decreasing linearly as the dose decreases. Because the scientific evidence does not conclusively demonstrate whether there is or is not an effect at low doses, the NRC assumes for radiation protection purposes, that even small doses have some chance of causing cancer. Thus, a principle of radiation protection is to do more than merely meet the allowed regulatory limits; doses should be kept as low as is reasonably achievable (ALARA). This is as true for natural carcinogens such as sunlight and natural radiation as it is for those that are manmade, such as cigarette smoke, smog, and x-rays.

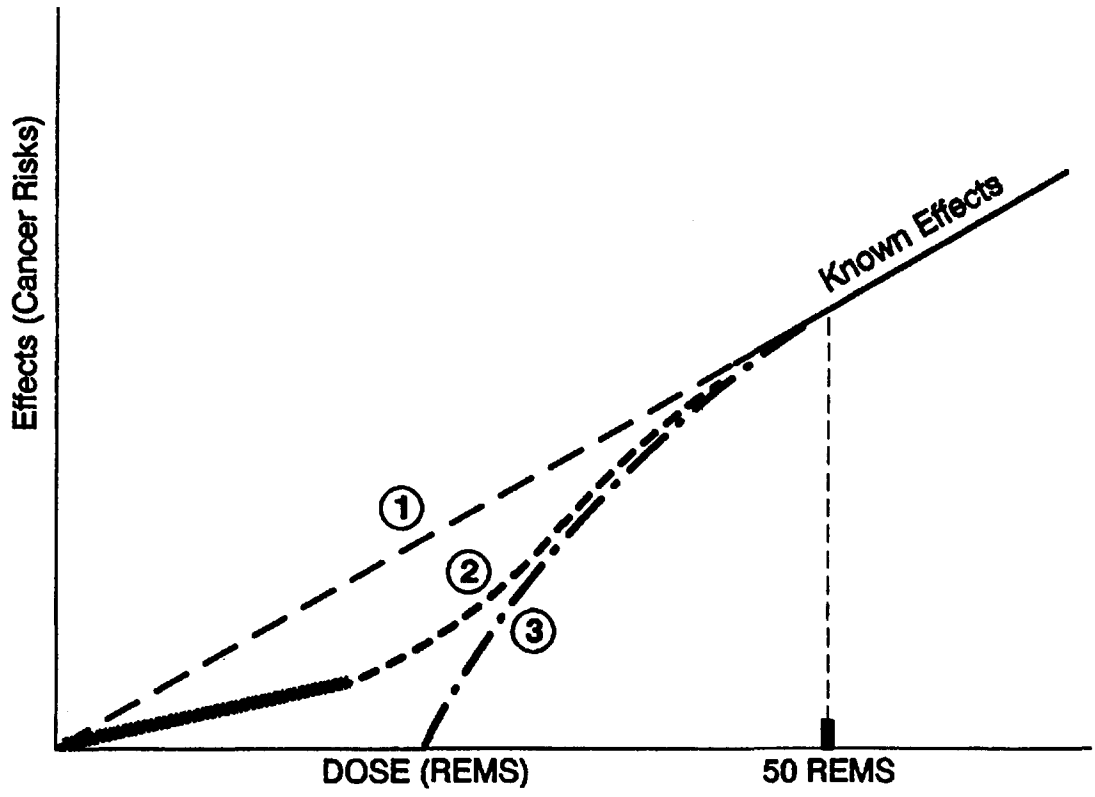

Figure 1. Some Proposed Models for How the Effects of Radiation Vary With Doses at Low Levels

10. How can we compare the risk of cancer from radiation to other kinds of health risks?

One way to make these comparisons is to compare the average number of days of life expectancy lost because of the effects associated with each particular health risk. Estimates are calculated by looking at a large number of persons, recording the age when death occurs from specific causes, and estimating the average number of days of life lost as a result of these early deaths. The total number of days of life lost is then averaged over the total observed group.

Several studies have compared the average days of life lost from exposure to radiation with the number of days lost as a result of being exposed to other health risks. The word "average" is important because an individual who gets cancer loses about 15 years of life expectancy, while his or her coworkers do not suffer any loss.

Some representative numbers are presented in Table 1. For categories of NRC-regulated industries with larger doses, the average measurable occupational dose in 1993 was 0.31 rem (0.0031 Sv). A simple calculation based on the article by Cohen and Lee (Ref. 10) shows that 0.3 rem (0.003 Sv) per year from age 18 to 65 results in an average loss of 15 days. These estimates indicate that the health risks from occupational radiation exposure are smaller than the risks associated with many other events or activities we encounter and accept in normal day-to-day activities.

It is also useful to compare the estimated average number of days of life lost from occupational exposure to radiation with the number of days lost as a result of working in several types of industries. Table 2 shows average days of life expectancy lost as a result of fatal work-related accidents. Table 2 does not include non-accident types of occupational risks such as occupational disease and stress because the data are not available.

These comparisons are not ideal because we are comparing the possible effects of chronic exposure to radiation to different kinds of risk such as accidental death, in which death is inevitable if the event occurs. This is the best we can do because good data are not available on chronic exposure to other workplace carcinogens. Also, the estimates of loss of life expectancy for workers from radiation-induced cancer do not take into consideration the competing effect on the life expectancy of the workers from industrial accidents.

11. What are the health risks from radiation exposure to the embryo/fetus?

During certain stages of development, the embryo/fetus is believed to be more sensitive to radiation damage than adults. Studies of atomic bomb survivors exposed to acute radiation doses exceeding 20 rads (0.2 Gy) during pregnancy show that children born after receiving these doses have a higher risk of mental retardation. Other studies suggest that an association exists between exposure to diagnostic x-rays before birth and carcinogenic effects in childhood and in adult life. Scientists are uncertain about the magnitude of the risk. Some studies show the embryo/fetus to be more sensitive to radiation-induced cancer than adults, but other studies do not. In recognition of the possibility of increased radiation sensitivity, and because dose to the

Table 1 Estimated Loss of Life Expectancy from Health Risks[a]

Health Risk	*Estimate of Life Expectancy Lost (average)*	
Smoking 20 cigarettes a day		6 years
Overweight (by 15%)		2 years
Alcohol consumption (U.S. average)		1 year
All accidents combined		1 year
Motor vehicle accidents	207 days	
Home accidents	74 days	
Drowning	24 days	
All natural hazards (earthquake, lightning, flood, etc.)		7 days
Medical radiation		6 days
Occupational Exposure		
0.3 rem/y from age 18 to 65	15 days	
1 rem/y from age 18 to 65	51 days	

[a]Adapted from Reference 10.

Table 2 Estimated Loss of Life Expectancy from Industrial Accidents[a]

Industry Type	*Estimated Days of Life Expectancy Lost (Average)*
All industries	60
Agriculture	320
Construction	227
Mining and Quarrying	167
Transportation and Public Utilities	160
Government	60
Manufacturing	40
Trade	27
Services	27

[a]Adapted from Reference 10.

embryo/fetus is involuntary on the part of the embryo/fetus, a more restrictive dose limit has been established for the embryo/fetus of a declared pregnant radiation worker. See Regulatory Guide 8.13, "Instruction Concerning Prenatal Radiation Exposure."

If an occupationally exposed woman declares her pregnancy in writing, she is subject to the more restrictive dose limits for the embryo/fetus during the remainder of the pregnancy. The dose limit of 500 mrems (5 mSv) for the total gestation period applies to the embryo/fetus and is controlled by restricting the exposure to the declared pregnant woman. Restricting the woman's occupational exposure, if she declares her pregnancy, raises questions about individual privacy rights, equal employment opportunities, and the possible loss of income. Because of these concerns, the declaration of pregnancy by a female radiation worker is voluntary. Also, the declaration of pregnancy can be withdrawn for any reason, for example, if the woman believes that her benefits from receiving the occupational exposure would outweigh the risk to her embryo/fetus from the radiation exposure.

12. Can a worker become sterile or impotent from normal occupational radiation exposure?

No. Temporary or permanent sterility cannot be caused by radiation at the levels allowed under NRC's occupational limits. There is a threshold below which these effects do not occur. Acute doses on the order of 10 rems (0.1 Sv) to the testes can result in a measurable but temporary reduction in sperm count. Temporary sterility (suppression of ovulation) has been observed in women who have received acute doses of 150 rads (1.5 Gy). The estimated threshold (acute) radiation dose for induction of permanent sterility is about 200 rads (2 Gy) for men and about 350 rads (3.5 Gy) for women (Refs. 1 and 4). These doses are far greater than the NRC s occupational dose limits for workers.

Although acute doses can affect fertility by reducing sperm count or suppressing ovulation, they do not have any direct effect on one's ability to function sexually. No evidence exists to suggest that exposures within the NRC's occupational limits have any effect on the ability to function sexually.

13. What are the NRC occupational dose limits?

For adults, an annual limit that does not exceed:

- 5 rems (0.05 Sv) for the total effective dose equivalent (TEDE), which is the sum of the deep dose equivalent (DDE) from external exposure to the whole body and the committed effective dose equivalent (CEDE) from intakes of radioactive material.
- 50 rems (0.5 Sv) for the total organ dose equivalent (TODE), which is the sum of the DDE from external exposure to the whole body and the committed dose equivalent (CDE) from intakes of radioactive material to any individual organ or tissue, other than the lens of the eye.
- 15 rems (0.15 Sv) for the lens dose equivalent (LDE), which is the external dose to the lens of the eye.
- 50 rems (0.5 Sv) for the shallow dose equivalent (SDE), which is the external dose to the skin or to any extremity.

For minor workers, the annual occupational dose limits are 10 percent of the dose limits for adult workers.

For protection of the embryo/fetus of a declared pregnant woman, the dose limit is 0.5 rem (5 mSv) during the entire pregnancy.

The occupational dose limit for adult workers of 5 rems (0.05 Sv) TEDE is based on consideration of the potential for delayed biological effects. The 5-rem (0.05 Sv) limit, together with application of the concept of keeping occupational doses ALARA, provides a level of risk of delayed effects considered acceptable by the NRC. The limits for individual organs are below the dose levels at which early biological effects are observed in the individual organs.

The dose limit for the embryo/fetus of a declared pregnant woman is based on a consideration of the possibility of greater sensitivity to radiation of the embryo/fetus and the involuntary nature of the exposure.

14. What is meant by ALARA?

ALARA means "as low as is reasonably achievable." In addition to providing an upper limit on an individual's permissible radiation dose, the NRC requires that its licensees establish radiation protection

programs and use procedures and engineering controls to achieve occupational doses, and doses to the public, as far below the limits as is reasonably achievable. "Reasonably achievable" also means "to the extent practicable." What is practicable depends on the purpose of the job, the state of technology, the costs for averting doses, and the benefits. Although implementation of the ALARA principle is a required integral part of each licensee's radiation protection program, it does not mean that each radiation exposure must be kept to an absolute minimum, but rather that "reasonable" efforts must be made to avert dose. In practice, ALARA includes planning tasks involving radiation exposure so as to reduce dose to individual workers and the work group.

There are several ways to control radiation doses, e.g., limiting the time in radiation areas, maintaining distance from sources of radiation, and providing shielding of radiation sources to reduce dose. The use of engineering controls, from the design of facilities and equipment to the actual set-up and conduct of work activities, is also an important element of the ALARA concept.

An ALARA analysis should be used in determining whether the use of respiratory protection is advisable. In evaluating whether or not to use respirators, the goal should be to achieve the optimal sum of external and internal doses. For example, the use of respirators can lead to increased work time within radiation areas, which increases external dose. The advantage of using respirators to reduce internal exposure must be evaluated against the increased external exposure and related stresses caused by the use of respirators. Heat stress, reduced visibility, and reduced communication associated with the use of respirators could expose a worker to far greater risks than are associated with the internal dose avoided by use of the respirator. To the extent practical, engineering controls, such as containments and ventilation systems, should be used to reduce workplace airborne radioactive materials.

15. What are background radiation exposures?

The average person is constantly exposed to ionizing radiation from several sources. Our environment and even the human body contain naturally occurring radioactive materials (e.g., potassium-40) that contribute to the radiation dose that we receive. The largest source of natural background radiation exposure is terrestrial radon, a colorless, odorless, chemically inert gas, which causes about 55 percent of our average, nonoccupational exposure. Cosmic radiation originating in space contributes additional exposure. The use of x-rays and radioactive materials in medicine and dentistry adds to our population exposure. As shown below in Table 3, the average person receives an annual radiation dose of about 0.36 rem (3.6 mSv). By age 20, the average person will accumulate over 7 rems (70 mSv) of dose. By age 50, the total dose is up to 18 rems (180 mSv). After 70 years of exposure this dose is up to 25 rems (250 mSv).

Table 3 Average Annual Effective Dose Equivalent to Individuals in the U.S.[a]

Source	*Effective Dose Equivalent (mrems)*	
Natural		
Radon	200	
Other than Radon	100	
Total		300
Nuclear Fuel Cycle		0.05
Consumer Products[b]		9
Medical		
Diagnostic X-rays	39	
Nuclear Medicine	14	
Total		53
Total		about 360 mrems/year

[a]Adapted from Table 8.1, NCRP 93 (Ref. 11).

[b]Includes building material, television receivers, luminous watches, smoke detectors, etc. (from Table 5.1, NCRP 93, Ref. 11).

16. What are the typical radiation doses received by workers?

For 1993, the NRC received reports on about a quarter of a million people who were monitored for occupational exposure to radiation. Almost half of those monitored had no measurable doses. The other half had an average dose of about 310 mrem (3.1 mSv) for the year. Of these, 93 percent received an annual dose of less than 1 rem (10 mSv); 98.7 percent received less than 2 rems (20 mSv); and the highest reported dose was for two individuals who each received between 5 and 6 rems (50 and 60 mSv).

Table 4 lists average occupational doses for workers (persons who had measurable doses) in various occupations based on 1993 data. It is important to note that beginning in 1994, licensees have been required to sum external and internal doses and certain licensees are required to submit annual reports. Certain types of licensees such as nuclear fuel fabricators may report a significant increase in worker doses because of the exposure to long-lived airborne radionuclides and the requirement to add the resultant internal dose to the calculation of occupational doses.

Table 4 Reported Occupational Doses for 1993[a]

Occupational Subgroup	Average Measurable Dose per Worker (millirems)
Industrial Radiography	540
Commercial Nuclear Power Reactors	310
Manufacturing and Distribution of Radioactive Materials	300
Low-Level Radioactive Waste Disposal	270
Independent Spent Nuclear Fuel Storage	260
Nuclear Fuel Fabrication	130

[a]From Table 3.1 in NUREG-0713 (Ref. 9).

17. How do I know how much my occupational dose (exposure) is?

If you are likely to receive more than 10 percent of the annual dose limits, the NRC requires your employer, the NRC licensee, to monitor your dose, to maintain records of your dose, and, at least on an annual basis for the types of licensees listed in 10 CFR 20.2206, "Reports of Individual Monitoring," to inform both you and the NRC of your dose. The purpose of this monitoring and reporting is so that the NRC can be sure that licensees are complying with the occupational dose limits and the ALARA principle.

External exposures are monitored by using individual monitoring devices. These devices are required to be used if it appears likely that external exposure will exceed 10 percent of the allowed annual dose, i.e., 0.5 rem (5 mSv). The most commonly used monitoring devices are film badges, thermoluminescence dosimeters (TLDs), electronic dosimeters, and direct reading pocket dosimeters.

With respect to internal exposure, your employer is required to monitor your occupational intake of radioactive material and assess the resulting dose if it appears likely that you will receive greater than 10 percent of the annual limit on intake (ALI) from intakes in 1 year. Internal exposure can be estimated by measuring the radiation emitted from the body (for example, with a "whole body counter") or by measuring the radioactive materials contained in biological samples such as urine or feces. Dose estimates can also be made if one knows how much radioactive material was in the air and the length of time during which the air was breathed.

18. What happens if a worker exceeds the annual dose limit?

If a worker receives a dose in excess of any of the annual dose limits, the regulations prohibit any occupational exposure during the remainder of the year in which the limit is exceeded. The licensee is also required to file an overexposure report with the NRC and provide a copy to the individual who received the dose. The licensee may be subject to NRC enforcement action such as a fine (civil penalty), just as individuals are subject to a traffic fine for exceeding a speed limit. The fines and, in some serious or repetitive cases, suspension of a license are intended to encourage licensees to comply with the regulations.

Radiation protection limits do not define safe or unsafe levels of radiation exposure. Exceeding a limit does not mean that you will get cancer. For radiation protection purposes, it is assumed that risks are related to the size of the radiation dose. Therefore, when your dose is higher your risk is also considered to be higher. These limits are similar to highway speed limits. If you drive at 70 mph, your risk is higher than at 55 mph, even though you may not actually have an accident. Those who set speed limits have determined that the risks of driving in excess of the speed limit are not acceptable. In the same way, the revised 10 CFR Part 20 establishes a limit for normal occupational exposure of 5 rems (0.05 Sv) a year. Although you will not necessarily get cancer or some other radiation effect at doses above the limit, it does mean that the licensee's safety program has failed in some way. Investigation is warranted to determine the cause and correct the conditions leading to the dose in excess of the limit.

19. What is meant by a "planned special exposure"?

A "planned special exposure" (PSE) is an infrequent exposure to radiation, separate from and in addition to the radiation received under the annual occupational limits. The licensee can authorize additional dose in any one year that is equal to the annual occupational dose limit as long as the individual's total dose from PSEs does not exceed five times the annual dose limit during the individual's lifetime. For example, licensees may authorize PSEs for an adult radiation worker to receive doses up to an additional 5 rems (0.05 Sv) in a year above the 5-rem (0.05-Sv) annual TEDE occupational dose limit. Each worker is limited to no more than 25 rems (0.25 Sv) from planned special exposures in his or her lifetime. Such exposures are only allowed in exceptional situations when alternatives for avoiding the additional exposure are not available or are impractical.

Before the licensee authorizes a PSE, the licensee must ensure that the worker is informed of the purpose and circumstances of the planned operation, the estimated doses expected, and the procedures to keep the doses ALARA while considering other risks that may

be present. (See Regulatory Guide 8.35, "Planned Special Exposures.")

20. Why do some facilities establish administrative control levels that are below the NRC limits?

There are two reasons. First, the NRC regulations state that licensees must take steps to keep exposures to radiation ALARA. Specific approval from the licensee for workers to receive doses in excess of administrative limits usually results in more critical risk-benefit analyses as each additional increment of dose is approved for a worker. Secondly, an administrative control level that is set lower than the NRC limit provides a safety margin designed to help the licensee avoid doses to workers in excess of the limit.

21. Why aren't medical exposures considered as part of a worker's allowed dose?

NRC rules exempt medical exposure, but equal doses of medical and occupational radiation have equal risks. Medical exposure to radiation is justified for reasons that are quite different from the reasons for occupational exposure. A physician prescribing an x-ray, for example, makes a medical judgment that the benefit to the patient from the resulting medical information justifies the risk associated with the radiation. This judgment may or may not be accepted by the patient. Similarly, each worker must decide on the benefits and acceptability of occupational radiation risk, just as each worker must decide on the acceptability of any other occupational hazard.

Consider a worker who receives a dose of 3 rems (0.03 Sv) from a series of x-rays in connection with an injury or illness. This dose and any associated risk must be justified on medical grounds. If the worker had also received 2 rems (0.02 Sv) on the job, the combined dose of 5 rems (0.05 Sv) would in no way incapacitate the worker. Restricting the worker from additional job exposure during the remainder of the year would not have any effect on the risk from the 3 rems (0.03 Sv) already received from the medical exposure. If the individual worker accepts the risks associated with the x-rays on the basis of the medical benefits and accepts the risks associated with job-related exposure on the basis of employment benefits, it would be unreasonable to restrict the worker from employment involving exposure to radiation for the remainder of the year.

22. How should radiation risks be considered in an emergency?

Emergencies are "unplanned" events in which actions to save lives or property may warrant additional doses for which no particular limit applies. The revised 10 CFR Part 20 does not set any dose limits for emergency or lifesaving activities and states that nothing in Part 20 "shall be construed as limiting actions that may be necessary to protect health and safety."

Rare situations may occur in which a dose in excess of occupational limits would be unavoidable in order to carry out a lifesaving operation or to avoid a large dose to large populations. However, persons called upon to undertake any emergency operation should do so only on a voluntary basis and with full awareness of the risks involved.

For perspective, the Environmental Protection Agency (EPA) has published emergency dose guidelines (Ref. 2). These guidelines state that doses to all workers during emergencies should, to the extent practicable, be limited to 5 rems (0.05 Sv). The EPA further states that there are some emergency situations for which higher limits may be justified. The dose resulting from such emergency exposures should be limited to 10 rems (0.1 Sv) for protecting valuable property, and to 25 rems (0.25 Sv) for lifesaving activities and the protection of large populations. In the context of this guidance, the dose to workers that is incurred for the protection of large populations might be considered justified for situations in which the collective dose to others that is avoided as a result of the emergency operation is significantly larger than that incurred by the workers involved.

Table 5 presents the estimates of the fatal cancer risk for a group of 1,000 workers of various ages, assuming that each worker received an acute dose of 25 rems (0.25 Sv) in the course of assisting in an emergency. The estimates show that a 25-rem emergency dose might increase an individual's chances of developing fatal cancer from about 20% to about 21%.

Table 5
Risk of Premature Death from Exposure to 25-Rems (0.25-Sv) Acute Dose

Age at Exposure (years)	*Estimated Risk of Premature Death (Deaths per 1,000 Persons Exposed)*
20–30	9.1
30–40	7.2
40–50	5.3
50–60	3.5

Source: EPA–400–R–92–001 (Ref. 2).

23. How were radiation dose limits established?

The NRC radiation dose limits in 10 CFR Part 20 were established by the NRC based on the recommendations of the ICRP and NCRP as endorsed in Federal radiation protection guidance developed by the EPA

(Ref. 12). The limits were recommended by the ICRP and NCRP with the objective of ensuring that working in a radiation-related industry was as safe as working in other comparable industries. The dose limits and the principle of ALARA should ensure that risks to workers are maintained indistinguishable from risks from background radiation.

24. Several scientific reports have recommended that the NRC establish lower dose limits. Does the NRC plan to reduce the regulatory limits?

Since publication of the NRC's proposed rule in 1986, the ICRP in 1990 revised its recommendations for radiation protection based on newer studies of radiation risks (Ref. 13), and the NCRP followed with a revision to its recommendations in 1993. The ICRP recommended a limit of 10 rems (0.1 Sv) effective dose equivalent (from internal and external sources), over a 5-year period with no more than 5 rems (0.05 Sv) in 1 year (Ref. 13). The NCRP recommended a cumulative limit in rems, not to exceed the individual's age in years, with no more than 5 rems (0.05 Sv) in any year (Ref. 14).

The NRC does not believe that additional reductions in the dose limits are required at this time. Because of the practice of maintaining radiation exposures ALARA (as low as is reasonably achievable), the average radiation dose to occupationally exposed persons is well below the limits in the current Part 20 that became mandatory January 1, 1994, and the average doses to radiation workers are below the new limits recommended by the ICRP and the NCRP.

25. What are the options if a worker decides that the risks associated with occupational radiation exposure are too high?

If the risks from exposure to occupational radiation are unacceptable to a worker, he or she can request a transfer to a job that does not involve exposure to radiation. However, the risks associated with the exposure to radiation that workers, on the average, actually receive are comparable to risks in other industries and are considered acceptable by the scientific groups that have studied them. An employer is not obligated to guarantee a transfer if a worker decides not to accept an assignment that requires exposure to radiation.

Any worker has the option of seeking other employment in a nonradiation occupation. However, the studies that have compared occupational risks in the nuclear industry to those in other job areas indicate that nuclear work is relatively safe. Thus, a worker may find different kinds of risk but will not necessarily find significantly lower risks in another job.

26. Where can one get additional information on radiation risk?

The following list suggests sources of useful information on radiation risk:

- The employer—the radiation protection or health physics office where a worker is employed.
- Nuclear Regulatory Commission Regional Offices:

King of Prussia, Pennsylvania	(610) 337-5000
Atlanta, Georgia	(404) 331-4503
Lisle, Illinois	(708) 829-9500
Arlington, Texas	(817) 860-8100

- U.S. Nuclear Regulatory Commission
  Headquarters
  Radiation Protection & Health Effects Branch
  Office of Nuclear Regulatory Research
  Washington, DC 20555
  Telephone: (301) 415-6187
- Department of Health and Human Services
  Center for Devices and Radiological Health
  1390 Piccard Drive, MS HFZ-1
  Rockville, MD 20850
  Telephone: (301) 443-4690
- U.S. Environmental Protection Agency
  Office of Radiation and Indoor Air
  Criteria and Standards Division
  401 M Street NW.
  Washington, DC 20460
  Telephone: (202) 233-9290

REFERENCES

1. B.R. Scott et al., "Health Effects Model for Nuclear Power Plant Accident Consequence Analysis," Part I: *Introduction, Integration, and Summary*, U.S. Nuclear Regulatory Commission, NUREG/CR-4214, Revision 2, Part I, October 1993.*

2. U.S. Environmental Protection Agency, *Manual of Protective Action Guides and Protective Actions for Nuclear Incidents*, EPA-400-R-92-001, May 1992.

3. International Commission on Radiological Protection, *Annals of the ICRP, Risks Associated with Ionising Radiation*, Volume 22, No.1, Pergamon Press, Oxford, UK, 1991.

4. National Research Council, *Health Effects of Exposure to Low Levels of Ionizing Radiation*, Report of the Committee on the Biological Effects of Ionizing Radiation (BEIR V), National Academy Press, Washington, DC, 1990.

5. United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), *Sources, Effects and Risks of Ionizing Radiation*, Report E.88.IX.7, United Nations, New York, 1988.

6. United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), *Sources and Effects of Ionizing Radiation*, United Nations, New York, 1993.

7. National Council on Radiation Protection and Measurements, *New Dosimetry at Hiroshima and Nagasaki and Its Implications for Risk Estimates*, Proceedings of the Twenty-third Annual Meeting of the National Council on Radiation Protection and Measurements Held on April 8-9, 1987 (1988).

8. National Council on Radiation Protection and Measurements, *Comparative Carcinogenicity of Ionizing Radiation and Chemicals*, NCRP Report No. 96, March 1989.

9. C.T. Raddatz and D. Hagemeyer, "Occupational Radiation Exposure at Commercial Nuclear Power Reactors and Other Facilities, 1993," U.S. Nuclear Regulatory Commission, NUREG-0713, Volume 15, January 1995.*

10. B.L. Cohen and I.S. Lee, "Catalog of Risks Extended and Updated," *Health Physics*, Vol. 61, September 1991.

11. National Council on Radiation Protection and Measurements, *Ionizing Radiation Exposure of the Population of the United States*, NCRP Report No. 93, September 1987.

12. U.S. Environmental Protection Agency, "Radiation Protection Guidance to Federal Agencies for Occupational Exposure," *Federal Register*, Vol. 52, No. 17, January 27, 1987.

13. International Commission on Radiological Protection, *1990 Recommendations of the International Commission on Radiological Protection*, ICRP Publication 60, Pergamon Press, Oxford, UK, 1991.

14. National Council on Radiation Protection and Measurements, *Limitation of Exposure to Ionizing Radiation*, NCRP Report No. 116, March 1993.

*Copies are available for inspection or copying for a fee from the NRC Public Document Room at 2120 L Street NW., Washington, DC; the PDR's mailing address is Mail Stop LL-6, Washington, DC 20555; telephone (202) 634-3273; fax (202) 634-3343. Copies may be purchased at current rates from the U.S. Government Printing Office, P.O. Box 37082, Washington, DC 20402-9328 (telephone (202) 512-2249); or from the National Technical Information Service by writing NTIS at 5285 Port Royal Road, Springfield, VA 22161.

BIBLIOGRAPHY

Abrahamson, S., *et al.*, "Health Effects Models for Nuclear Power Plant Accident Consequence Analysis," Part II: *Scientific Bases for Health Effects Models*, U.S. Nuclear Regulatory Commission, NUREG/CR-4214, Rev. 1, Part II, May 1989.[1]

Abrahamson, S., *et al.*, "Health Effects Models for Nuclear Power Plant Accident Consequence Analysis, Modifications of Models Resulting From Recent Reports on Health Effects of Ionizing Radiation, Low LET Radiation," Part II: *Scientific Basis for Health Effects Models*, U.S. Nuclear Regulatory Commission, NUREG/CR-4214, Rev.1, Part II, Addendum 1, August 1991.[1]

Abrahamson, S., *et al.*, "Health Effects Models for Nuclear Power Plant Accident Consequence Analysis, Modifications of Models Resulting From Addition of Effects of Exposure to Alpha-Emitting Radionuclides," Part II: *Scientific Bases for Health Effects Models*, U.S. Nuclear Regulatory Commission, NUREG/CR-4214, Rev.1, Part II, Addendum 2, May 1993.[1]

International Commission on Radiological Protection, *Radiation Protection*, Recommendations of the International Commission on Radiological Protection, ICRP Publication 26, Pergamon Press, Oxford, UK, January 1977.

National Council on Radiation Protection and Measurements, *Public Radiation Exposure From Nuclear Power Generation in the United States*, NCRP Report No. 92, December 1987.

National Council on Radiation Protection and Measurements, *Exposure of the Population in the United States and Canada from Natural Background Radiation*, NCRP Report No. 94, December 1987.

National Council on Radiation Protection and Measurements, *Exposure of the U.S. Population From Occupational Radiation*, NCRP Report No. 101, June 1989.

National Council on Radiation Protection and Measurements, *Risk Estimates for Radiation Protection*, NCRP Report No. 115, December 1993.

National Council on Radiation Protection and Measurements, *Limitation of Exposure to Ionizing Radiation*, NCRP Report No. 116, March 1993.

National Safety Council, *Accident Facts, 1993 Edition*, Itasca, Illinois, 1993.

U.S. Environmental Protection Agency, "Radiation Protection Guidance to Federal Agencies for Occupational Exposure," *Federal Register*, Vol. 52, No. 17, January 27, 1987.

U.S. Nuclear Regulatory Commission, "Instruction Concerning Prenatal Radiation Exposure," Regulatory Guide 8.13, Revision 2, December 1987.[2]

U.S. Nuclear Regulatory Commission, "Monitoring Criteria and Methods To Calculate Occupational Radiation Doses," Regulatory Guide 8.34, July 1992.[2]

U.S. Nuclear Regulatory Commission, "Planned Special Exposures," Regulatory Guide 8.35, June 1992.[2]

U.S. Nuclear Regulatory Commission, "Radiation Dose to the Embryo/Fetus," Regulatory Guide 8.36, July 1992.[2]

[1]Copies are available for inspection or copying for a fee from the NRC Public Document Room at 2120 L Street NW., Washington, DC; the PDR's mailing address is Mail Stop LL-6, Washington, DC 20555-0001; telephone (202) 634-3273; fax (202) 634-3343. Copies may be purchased at current rates from the U.S. Government Printing Office, P.O. Box 37082, Washington, DC 20402-9328 (telephone (202) 512-2249); or from the National Technical Information Service by writing NTIS at 5285 Port Royal Road, Springfield, VA 22161.

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REGULATORY ANALYSIS

A separate regulatory analysis was not prepared for this Revision 1 to Regulatory Guide 8.29. A value/impact statement, which evaluated essentially the same subjects as are discussed in a regulatory analysis, accompanied Regulatory Guide 8.29 when it was issued in July 1981.

This Revision 1 to Regulatory Guide 8.29 is needed to conform with the Revised 10 CFR Part 20, "Standards for Protection Against Radiation," as published May 21, 1991 (56 FR 23360). The regulatory analysis prepared for 10 CFR Part 20 provides the regulatory basis for this Revision 1 of Regulatory Guide 8.29, and it examines the costs and benefits of the rule as implemented by the guide. A copy of the "Regulatory Analysis for the Revision of 10 CFR Part 20" (PNL-6712, November 1988), is available for inspection and copying for a fee in the NRC's Public Document Room at 2120 L Street NW., Washington, DC 20555-0001.

Appendix 10

Prenatal Radiation Exposure

U.S. NUCLEAR REGULATORY COMMISSION

Revision 3
June 1999

REGULATORY GUIDE

OFFICE OF NUCLEAR REGULATORY RESEARCH

REGULATORY GUIDE 8.13

(Draft was issued as DG-8014)

INSTRUCTION CONCERNING PRENATAL RADIATION EXPOSURE

A. INTRODUCTION

The Code of Federal Regulations in 10 CFR Part 19, "Notices, Instructions and Reports to Workers: Inspection and Investigations," in Section 19.12, "Instructions to Workers," requires instruction in "the health protection problems associated with exposure to radiation and/or radioactive material, in precautions or procedures to minimize exposure, and in the purposes and functions of protective devices employed." The instructions must be "commensurate with potential radiological health protection problems present in the work place."

The Nuclear Regulatory Commission's (NRC's) regulations on radiation protection are specified in 10 CFR Part 20, "Standards for Protection Against Radiation"; and 10 CFR 20.1208, "Dose to an Embryo/Fetus," requires licensees to "ensure that the dose to an embryo/fetus during the entire pregnancy, due to occupational exposure of a declared pregnant woman, does not exceed 0.5 rem (5 mSv)." Section 20.1208 also requires licensees to "make efforts to avoid substantial variation above a uniform monthly exposure rate to a declared pregnant woman." A declared pregnant woman is defined in 10 CFR 20.1003 as a woman who has voluntarily informed her employer, in writing, of her pregnancy and the estimated date of conception.

This regulatory guide is intended to provide information to pregnant women, and other personnel, to help them make decisions regarding radiation exposure during pregnancy. This Regulatory Guide 8.13 supplements Regulatory Guide 8.29, "Instruction Concerning Risks from Occupational Radiation Exposure" (Ref. 1), which contains a broad discussion of the risks from exposure to ionizing radiation.

Other sections of the NRC's regulations also specify requirements for monitoring external and internal occupational dose to a declared pregnant woman. In 10 CFR 20.1502, "Conditions Requiring Individual Monitoring of External and Internal Occupational Dose," licensees are required to monitor the occupational dose to a declared pregnant woman, using an individual monitoring device, if it is likely that the declared pregnant woman will receive, from external sources, a deep dose equivalent in excess of 0.1 rem (1 mSv). According to Paragraph (e) of 10 CFR 20.2106, "Records of Individual Monitoring Results," the licensee must maintain records of dose to an embryo/fetus if monitoring was required, and the records of dose to the embryo/fetus must be kept with the records of dose to the declared pregnant woman. The declaration of pregnancy must be kept on file, but may be maintained separately from the dose records. The licensee must retain the re-

USNRC REGULATORY GUIDES

Regulatory Guides are issued to describe and make available to the public such information as methods acceptable to the NRC staff for implementing specific parts of the Commission's regulations, techniques used by the staff in evaluating specific problems or postulated accidents, and data needed by the NRC staff in its review of applications for permits and licenses. Regulatory guides are not substitutes for regulations, and compliance with them is not required. Methods and solutions different from those set out in the guides will be acceptable if they provide a basis for the findings requisite to the issuance or continuance of a permit or license by the Commission.

This guide was issued after consideration of comments received from the public. Comments and suggestions for improvements in these guides are encouraged at all times, and guides will be revised, as appropriate, to accommodate comments and to reflect new information or experience.

Written comments may be submitted to the Rules and Directives Branch, ADM, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001.

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quired form or record until the Commission terminates each pertinent license requiring the record.

The information collections in this regulatory guide are covered by the requirements of 10 CFR Parts 19 or 20, which were approved by the Office of Management and Budget, approval numbers 3150-0044 and 3150-0014, respectively. The NRC may not conduct or sponsor, and a person is not required to respond to, a collection of information unless it displays a currently valid OMB control number.

B. DISCUSSION

As discussed in Regulatory Guide 8.29 (Ref. 1), exposure to any level of radiation is assumed to carry with it a certain amount of risk. In the absence of scientific certainty regarding the relationship between low dose exposure and health effects, and as a conservative assumption for radiation protection purposes, the scientific community generally assumes that any exposure to ionizing radiation may cause undesirable biological effects and that the likelihood of these effects increases as the dose increases. At the occupational dose limit for the whole body of 5 rem (50 mSv) per year, the risk is believed to be very low.

The magnitude of risk of childhood cancer following in utero exposure is uncertain in that both negative and positive studies have been reported. The data from these studies "are consistent with a lifetime cancer risk resulting from exposure during gestation which is two to three times that for the adult" (NCRP Report No. 116, Ref. 2). The NRC has reviewed the available scientific literature and has concluded that the 0.5 rem (5 mSv) limit specified in 10 CFR 20.1208 provides an adequate margin of protection for the embryo/fetus. This dose limit reflects the desire to limit the total lifetime risk of leukemia and other cancers associated with radiation exposure during pregnancy.

In order for a pregnant worker to take advantage of the lower exposure limit and dose monitoring provisions specified in 10 CFR Part 20, the woman must declare her pregnancy in writing to the licensee. A form letter for declaring pregnancy is provided in this guide or the licensee may use its own form letter for declaring pregnancy. A separate written declaration should be submitted for each pregnancy.

C. REGULATORY POSITION

1. Who Should Receive Instruction

Female workers who require training under 10 CFR 19.12 should be provided with the information contained in this guide. In addition to the information contained in Regulatory Guide 8.29 (Ref. 1), this information may be included as part of the training required under 10 CFR 19.12.

2. Providing Instruction

The occupational worker may be given a copy of this guide with its Appendix, an explanation of the contents of the guide, and an opportunity to ask questions and request additional information. The information in this guide and Appendix should also be provided to any worker or supervisor who may be affected by a declaration of pregnancy or who may have to take some action in response to such a declaration.

Classroom instruction may supplement the written information. If the licensee provides classroom instruction, the instructor should have some knowledge of the biological effects of radiation to be able to answer questions that may go beyond the information provided in this guide. Videotaped presentations may be used for classroom instruction. Regardless of whether the licensee provides classroom training, the licensee should give workers the opportunity to ask questions about information contained in this Regulatory Guide 8.13. The licensee may take credit for instruction that the worker has received within the past year at other licensed facilities or in other courses or training.

3. Licensee's Policy on Declared Pregnant Women

The instruction provided should describe the licensee's specific policy on declared pregnant women, including how those policies may affect a woman's work situation. In particular, the instruction should include a description of the licensee's policies, if any, that may affect the declared pregnant woman's work situation after she has filed a written declaration of pregnancy consistent with 10 CFR 20.1208.

The instruction should also identify who to contact for additional information as well as identify who should receive the written declaration of pregnancy. The recipient of the woman's declaration may be identified by name (e.g., John Smith), position (e.g., immediate supervisor, the radiation safety officer), or department (e.g., the personnel department).

4. Duration of Lower Dose Limits for the Embryo/Fetus

The lower dose limit for the embryo/fetus should remain in effect until the woman withdraws the declaration in writing or the woman is no longer pregnant. If a declaration of pregnancy is withdrawn, the dose limit for the embryo/fetus would apply only to the time from the estimated date of conception until the time the declaration is withdrawn. If the declaration is

not withdrawn, the written declaration may be considered expired one year after submission.

5. Substantial Variations Above a Uniform Monthly Dose Rate

According to 10 CFR 20.1208(b), "The licensee shall make efforts to avoid substantial variation above a uniform monthly exposure rate to a declared pregnant woman so as to satisfy the limit in paragraph (a) of this section," that is, 0.5 rem (5 mSv) to the embryo/fetus. The National Council on Radiation Protection and Measurements (NCRP) recommends a monthly equivalent dose limit of 0.05 rem (0.5 mSv) to the embryo/fetus once the pregnancy is known (Ref. 2). In view of the NCRP recommendation, any monthly dose of less than 0.1 rem (1 mSv) may be considered as not a substantial variation above a uniform monthly dose rate and as such will not require licensee justification. However, a monthly dose greater than 0.1 rem (1 mSv) should be justified by the licensee.

D. IMPLEMENTATION

The purpose of this section is to provide information to licensees and applicants regarding the NRC staff's plans for using this regulatory guide.

Unless a licensee or an applicant proposes an acceptable alternative method for complying with the specified portions of the NRC's regulations, the methods described in this guide will be used by the NRC staff in the evaluation of instructions to workers on the radiation exposure of pregnant women.

REFERENCES

1. USNRC, "Instruction Concerning Risks from Occupational Radiation Exposure," Regulatory Guide 8.29, Revision 1, February 1996.

2. National Council on Radiation Protection and Measurements, *Limitation of Exposure to Ionizing Radiation*, NCRP Report No. 116, Bethesda, MD, 1993.

APPENDIX

QUESTIONS AND ANSWERS CONCERNING PRENATAL RADIATION EXPOSURE

1. Why am I receiving this information?

The NRC's regulations (in 10 CFR 19.12, "Instructions to Workers") require that licensees instruct individuals working with licensed radioactive materials in radiation protection as appropriate for the situation. The instruction below describes information that occupational workers and their supervisors should know about the radiation exposure of the embryo/fetus of pregnant women.

The regulations allow a pregnant woman to decide whether she wants to formally declare her pregnancy to take advantage of lower dose limits for the embryo/fetus. This instruction provides information to help women make an informed decision whether to declare a pregnancy.

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

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

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

If you choose to declare your pregnancy in writing, the licensee must take measures to limit the dose to your embryo/fetus to 0.5 rem (5 millisievert) during the entire pregnancy. This is one-tenth of the dose that an occupational worker may receive in a year. If you have already received a dose exceeding 0.5 rem (5 mSv) in the period between conception and the declaration of your pregnancy, an additional dose of 0.05 rem (0.5 mSv) is allowed during the remainder of the pregnancy. In addition, 10 CFR 20.1208, "Dose to an Embryo/Fetus," requires licensees to make efforts to avoid substantial variation above a uniform monthly dose rate so that all the 0.5 rem (5 mSv) allowed dose does not occur in a short period during the pregnancy.

This may mean that, if you declare your pregnancy, the licensee may not permit you to do some of your normal job functions if those functions would have allowed you to receive more than 0.5 rem, and you may not be able to have some emergency response responsibilities.

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

A lower dose limit for the embryo/fetus of a declared pregnant woman is based on a consideration of greater sensitivity to radiation of the embryo/fetus and the involuntary nature of the exposure. Several scientific advisory groups have recommended (References 1 and 2) that the dose to the embryo/fetus be limited to a fraction of the occupational dose limit.

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

The occurrence and severity of health effects caused by ionizing radiation are dependent upon the type and total dose of radiation received, as well as the time period over which the exposure was received. See Regulatory Guide 8.29, "Instruction Concerning Risks from Occupational Exposure" (Ref. 3), for more information. The main concern is embryo/fetal susceptibility to the harmful effects of radiation such as cancer.

6. Are there any risks of genetic defects?

Although radiation injury has been induced experimentally in rodents and insects, and in the experiments was transmitted and became manifest as hereditary disorders in their offspring, radiation has not been identified as a cause of such effect in humans. Therefore, the risk of genetic effects attributable to radiation exposure is speculative. For example, no genetic effects have been documented in any of the Japanese atomic bomb survivors, their children, or their grandchildren.

7. What if I decide that I do not want any radiation exposure at all during my pregnancy?

You may ask your employer for a job that does not involve any exposure at all to occupational radiation dose, but your employer is not obligated to provide you with a job involving no radiation exposure. Even if you receive no occupational exposure at all, your embryo/fetus will receive some radiation dose (on average 75 mrem (0.75 mSv)) during your pregnancy from natural background radiation.

The NRC has reviewed the available scientific literature and concluded that the 0.5 rem (5 mSv) limit

provides an adequate margin of protection for the embryo/fetus. This dose limit reflects the desire to limit the total lifetime risk of leukemia and other cancers. If this dose limit is exceeded, the total lifetime risk of cancer to the embryo/fetus may increase incrementally. However, the decision on what level of risk to accept is yours. More detailed information on potential risk to the embryo/fetus from radiation exposure can be found in References 2-10.

8. What effect will formally declaring my pregnancy have on my job status?

Only the licensee can tell you what effect a written declaration of pregnancy will have on your job status. As part of your radiation safety training, the licensee should tell you the company's policies with respect to the job status of declared pregnant women. In addition, before you declare your pregnancy, you may want to talk to your supervisor or your radiation safety officer and ask what a declaration of pregnancy would mean specifically for you and your job status.

In many cases you can continue in your present job with no change and still meet the dose limit for the embryo/fetus. For example, most commercial power reactor workers (approximately 93%) receive, in 12 months, occupational radiation doses that are less than 0.5 rem (5 mSv) (Ref. 11). The licensee may also consider the likelihood of increased radiation exposures from accidents and abnormal events before making a decision to allow you to continue in your present job.

If your current work might cause the dose to your embryo/fetus to exceed 0.5 rem (5 mSv), the licensee has various options. It is possible that the licensee can and will make a reasonable accommodation that will allow you to continue performing your current job, for example, by having another qualified employee do a small part of the job that accounts for some of your radiation exposure.

9. What information must I provide in my written declaration of pregnancy?

You should provide, in writing, your name, a declaration that you are pregnant, the estimated date of conception (only the month and year need be given), and the date that you give the letter to the licensee. A form letter that you can use is included at the end of these questions and answers. You may use that letter, use a form letter the licensee has provided to you, or write your own letter.

10. To declare my pregnancy, do I have to have documented medical proof that I am pregnant?

NRC regulations do not require that you provide medical proof of your pregnancy. However, NRC regulations do not preclude the licensee from requesting medical documentation of your pregnancy, especially if a change in your duties is necessary in order to comply with the 0.5 rem (5 mSv) dose limit.

11. Can I tell the licensee orally rather than in writing that I am pregnant?

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

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

No. The lower dose limits for pregnant women apply only if you have declared your pregnancy in writing. The United States Supreme Court has ruled (in *United Automobile Workers International Union v. Johnson Controls, Inc.*, 1991) that "Decisions about the welfare of future children must be left to the parents who conceive, bear, support, and raise them rather than to the employers who hire those parents" (Reference 7). The Supreme Court also ruled that your employer may not restrict you from a specific job "because of concerns about the next generation." Thus, the lower limits apply only if you choose to declare your pregnancy in writing.

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

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

14. What if I have a miscarriage or find out that I am not pregnant?

If you have declared your pregnancy in writing, you should promptly inform the licensee in writing that you are no longer pregnant. However, if you have not formally declared your pregnancy in writing, you need not inform the licensee of your nonpregnant status.

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

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

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

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

17. What if I work under contract at a licensed facility?

The regulations state that you should formally declare your pregnancy to the licensee in writing. The licensee has the responsibility to limit the dose to the embryo/fetus.

18. Where can I get additional information?

The references to this Appendix contain helpful information, especially Reference 3, NRC's Regulatory Guide 8.29, "Instruction Concerning Risks from Occupational Radiation Exposure," for general information on radiation risks. The licensee should be able to give this document to you.

For information on legal aspects, see Reference 7, "The Rock and the Hard Place: Employer Liability to Fertile or Pregnant Employees and Their Unborn Children—What Can the Employer Do?" which is an article in the journal *Radiation Protection Management*.

You may telephone the NRC Headquarters at (301) 415-7000. Legal questions should be directed to the Office of the General Counsel, and technical questions should be directed to the Division of Industrial and Medical Nuclear Safety.

You may also telephone the NRC Regional Offices at the following numbers: Region I, (610) 337-5000; Region II, (404) 562-4400; Region III, (630) 829-9500; and Region IV, (817) 860-8100. Legal questions should be directed to the Regional Counsel, and technical questions should be directed to the Division of Nuclear Materials Safety.

REFERENCES FOR APPENDIX

1. National Council on Radiation Protection and Measurements, *Limitation of Exposure to Ionizing Radiation*, NCRP Report No. 116, Bethesda, MD, 1993.

2. International Commission on Radiological Protection, *1990 Recommendations of the International Commission on Radiological Protection*, ICRP Publication 60, Ann. ICRP 21: No. 1-3, Pergamon Press, Oxford, UK, 1991.

3. USNRC, "Instruction Concerning Risks from Occupational Radiation Exposure," Regulatory Guide 8.29, Revision 1, February 1996.[1] (Electronically available at www.nrc.gov/NRC/RG/index.html)

4. Committee on the Biological Effects of Ionizing Radiations, National Research Council, *Health Effects of Exposure to Low Levels of Ionizing Radiation* (BEIR V), National Academy Press, Washington, DC, 1990.

5. United Nations Scientific Committee on the Effects of Atomic Radiation, *Sources and Effects of Ionizing Radiation*, United Nations, New York, 1993.

6. R. Doll and R. Wakeford, "Risk of Childhood Cancer from Fetal Irradiation," *The British Journal of Radiology*, 70, 130-139, 1997.

7. David Wiedis, Donald E. Jose, and Timm O. Phoebe, "The Rock and the Hard Place: Employer Liability to Fertile or Pregnant Employees and Their Unborn Children—What Can the Employer Do?" *Radiation Protection Management, 11,* 41-49, January/February 1994.

8. National Council on Radiation Protection and Measurements, *Considerations Regarding the Unintended Radiation Exposure of the Embryo, Fetus, or Nursing Child*, NCRP Commentary No. 9, Bethesda, MD, 1994.

9. National Council on Radiation Protection and Measurements, *Risk Estimates for Radiation Protection*, NCRP Report No. 115, Bethesda, MD, 1993.

10. National Radiological Protection Board, *Advice on Exposure to Ionising Radiation During Pregnancy*, National Radiological Protection Board, Chilton, Didcot, UK, 1998.

11. M.L. Thomas and D. Hagemeyer, "Occupational Radiation Exposure at Commercial Nuclear Power Reactors and Other Facilities, 1996," Twenty-Ninth Annual Report, NUREG-0713, Vol. 18, USNRC, 1998.[2]

[1]Single copies of regulatory guides, both active and draft, and draft NUREG documents may be obtained free of charge by writing the Reproduction and Distribution Services Section, OCIO, USNRC, Washington, DC 20555–0001, or by fax to (301)415–2289, or by email to <DISTRIBUTION@NRC.GOV>. Active guides may also be purchased from the National Technical Information Service on a standing order basis. Details on this service may be obtained by writing NTIS, 5285 Port Royal Road, Springfield, VA 22161. Copies of active and draft guides are available for inspection or copying for a fee from the NRC Public Document Room at 2120 L Street NW., Washington, DC; the PDR's mailing address is Mail Stop LL-6, Washington, DC 20555; telephone (202)634–3273; fax (202)634–3343.

[2]Copies are available at current rates from the U.S. Government Printing Office, P.O. Box 37082, Washington, DC 20402–9328 (telephone (202)512–1800); or from the National Technical Information Service by writing NTIS at 5285 Port Royal Road, Springfield, VA 22161. Copies are available for inspection or copying for a fee from the NRC Public Document Room at 2120 L Street NW., Washington, DC; the PDR's mailing address is Mail Stop LL-6, Washington, DC 20555; telephone (202)634–3273; fax (202)634–3343.

FORM LETTER FOR DECLARING PREGNANCY

This form letter is provided for your convenience. To make your written declaration of pregnancy, you may fill in the blanks in this form letter, you may use a form letter the licensee has provided to you, or you may write your own letter.

DECLARATION OF PREGNANCY

To:_____

In accordance with the NRC's regulations at 10 CFR 20.1208, "Dose to an Embryo/Fetus," I am declaring that I am pregnant. I believe I became pregnant in_____ (only the month and year need be provided).

I understand the radiation dose to my embryo/fetus during my entire pregnancy will not be allowed to exceed 0.5 rem (5 millisievert) (unless that dose has already been exceeded between the time of conception and submitting this letter). I also understand that meeting the lower dose limit may require a change in job or job responsibilities during my pregnancy.

_____

(Your signature)

_____

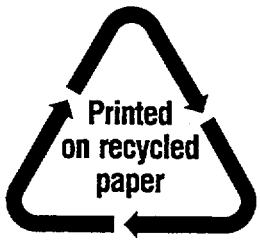
(Your name printed)

_____

(Date)

REGULATORY ANALYSIS

A separate regulatory analysis was not prepared for this regulatory guide. A regulatory analysis prepared for 10 CFR Part 20, "Standards for Protection Against Radiation" (56 FR 23360), provides the regulatory basis for this guide and examines the costs and benefits of the rule as implemented by the guide. A copy of the "Regulatory Analysis for the Revision of 10 CFR Part 20" (PNL-6712, November 1988) is available for inspection and copying for a fee at the NRC Public Document Room, 2120 L Street NW, Washington, DC, as an enclosure to Part 20 (56 FR 23360).



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Appendix 11

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
RADIATION PROTECTION COMMITTEE

POLICY REGARDING PREGNANT EMPLOYEES AND STAFF WHO ARE POTENTIALLY EXPOSED TO IONIZING RADIATION

Introduction:

Current regulations of the Massachusetts Department of Public Health (MDPH) governing the occupational exposure to ionizing radiation require that the radiation dose to the fetus of occupationally exposed declared pregnant women be held to 0.5 Rem (5 mSv) or less during the pregnancy. The National Council on Radiation Protection (NCRP) has recently recommended that this dose be controlled such that no more than 0.05 Rem (0.5 mSv) be delivered to the fetus in any one month.

For the majority of radiation workers in this institution, the occupational exposures received through normal work practices as measured by the film badges fall well below these more restrictive limits for declared pregnant workers. Hence, it is anticipated that there should generally be little difficulty in complying with the applicable limits. All radiation workers, women of child-bearing age especially, are encouraged to carefully monitor their film badge readings and become familiar with their potential sources of exposure and means of minimizing the same.

It is the responsibility of the MIT Radiation Protection Committee to formulate, implement and review radiation protection policies such that they are compliant with federal and state regulations. The purpose of this memo is to set forth the policy of this committee with respect to the occupational duties of pregnant employees who may be exposed to ionizing radiation.

MIT's Policy:

The following are the formal MIT policies for the employee who informs her supervisor that she believes she is pregnant.

1. **It is the responsibility of the pregnant radiation worker to decide when or whether she will formally declare her condition to her employer. Formal declaration of pregnancy by the woman is initiated when the Radiation Protection Program receives a completed copy of the RP-520 "Declaration of Pregnancy for Radiation Workers". This form must be completed by both the pregnant women and her supervisor. Undeclared pregnant radiation workers are protected under NRC regulations for all occupational workers.**

2. **In keeping with state and federal recommendations to hold embryo/fetus exposures ALARA (As Low As Reasonably Achievable), if the pregnant employee is currently assigned to duties whereby her potential exposure is significantly above the average of her peers in her department, she may request to be reassigned to duties involving lower potential for exposure for the duration of her pregnancy if such temporary reassignment is deemed administratively practical.**

3. **Pregnant radiation workers are encouraged to be particularly diligent in avoiding unnecessary exposure during their regular work assignment, by minimizing their time of exposure, maximizing their distance form the radiation source, and by taking maximum advantage of available protective equipment such as bench shields.**

4. **After reassignment, if practical, and while implementing the above procedure where practical to minimize potential radiation dose to the fetus, the pregnant employee will be expected to perform all duties assigned.**

5. **A copy of this policy will be given to all women radiation workers at the time of their training with the Radiation Protection Program. A second copy will be provided if and when a pregnant employee informs her supervisor of her pregnancy. The pregnant employee is encouraged to discuss the potential for fetal exposure and methods for controlling the same with her supervisor and the Radiation Protection Program in her consideration of this issue.**

The above policy is believed to be conservative in many respects. Typically radiation workers at MIT do not receive significant radiation exposures due to their work with radioactive materials. Average exposures for all radiation workers at MIT are less than 5% of the permissible levels. However, pregnant radiation workers will be carefully monitored to assure that they are kept as low as practical.

RP-520
4/97

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
DECLARATION OF PREGNANCY FOR RADIATION WORKERS

I. DECLARATION OF PREGNANCY

Name of Individual
Social Security Number
Date of Conception (Mo/Yr)
By providing this information to my immediate supervisor, in writing, I am declaring myself to be pregnant as of the date shown above. Under the provisions of 105 CMR 120.218 I understand that my exposure will not be allowed to exceed 5 mSv (500 mrem) during my pregnancy, from occupational exposure to radiation. I understand that this limit includes exposure I have already received. If my estimated exposure since the above date of conception has already exceeded 5 mSv (500 mrem), I understand that I will be limited to no more than 0.5 mSv (50 mrem) for the remainder of my pregnancy. If I should find out that I am not pregnant, or if my pregnancy is terminated, I will inform my supervisor as soon as practical.
Signature of Individual
Date Signed

II. DESCRIPTION OF CURRENT WORK WITH IONIZING RADIATION

Note principal radioactive materials used & include maximum amount used/use per experiment:

III. RECEIPT OF DECLARATION OF PREGNANCY

Name of Supervisor
Authorization Number
I have received notification from the above named woman that she is pregnant. I have explained to her the potential risks from exposure to radiation as provided in Regulatory Guide 8.13, Revision 3. I have evaluated her prior exposure and established appropriate limits to control the dose to the developing embryo/fetus in accordance with limits in 105 CMR 120.218. I have explained to her options for reducing her exposure to as low as reasonably achievable (ALARA).
Signature of Supervisor
Date Signed

Appendix 12

120.750: NOTICES INSTRUCTIONS AND REPORTS TO WORKERS: INSPECTIONS

120.751: Purpose and Scope

105 CMR 120-750 established requirements for notices, instructions and reports by licensees or registrants to individuals engaged in activities under a license or registration and options available to such individuals in connection with Agency inspections of licensees or registrants to ascertain compliance with the provisions of M.G.L. c. III, " 3, 5M, 5N, 50, and 5P and regulations, orders, and licenses issued thereunder to all persons who receive, possess, use, own, or transfer sources of radiation registered with or licensed by the Agency pursuant to 105 CMR 120.020 and 105 CMR 120.100.

120.752: Posting of Notices to Workers

(A) **Each licensee or registrant shall post current copies of the following documents:**

(1) **The regulations in 105 CMR 120.750 an in 105 CMR 120.200,**

(2) **The license, certificates of registration, conditions or documents incorporated into the license by reference and amendments thereto;**

(3) **The operating procedures applicable to activities under the license or registration; and,**

(4) **Any notice of violation involving radiological working conditions, proposed imposition of civil penalty, or under order issued pursuant to 105 CMR 120.200, and any response from the licensee or registrant.**

(B) **If posting a document specified in 105 CMR 120.752(A)(1), (2) or (3) is not practicable, the licensee or registrant may post a notice which describes the document and states where it may be examined.**

(C) **Form MRCP 120.750-1** A**Notice to Employees@, shall be posted by each licensee or registrant as required by 105 CMR 120.000.**

(D) **Agency documents posted pursuant to 105 CMR 120.752(A)(4) shall be posted within five working days after receipt of the documents from the Agency; the licensee's or registrants response, if any, shall be posted within five working days after dispatch from the licensee or registrant. Such documents shall remain posted for a minimum of five working days or action correcting the violation has been completed, whichever is later.**

(E) **Documents, notices, or forms posted pursuant to 105 CMR 120.752 shall appear in a sufficient number of places to permit individuals engaged in work under the license or registration to observe them on the way to or from any particular work location to**

which the document applies, shall be conspicuous, and shall be replaced if defaced or altered.

120.753: Instructions to Workers

(A) **All individuals likely to receive an occupational dose:**

(1) **shall be kept informed of the storage, transfer, or use of sources of radiation in the licensee's or registrants work place;**

(2) **shall be instructed in the health protection problems associated with exposure to radiation or radioactive material to the individual and potential offspring, in precautions or procedures to minimize exposure, and in the purposes and functions of protective devices employed;**

(3) **Shall be instructed in, and instructed to observe, to the extent within the worker's control, the applicable provisions of 105 CMR 120.000 and licenses for the protection of personnel from exposures to radiation or radioactive material.**

(4) **Shall be instructed of their responsibility to report promptly to the licensee or registrant any condition which may constitute, lead to, or cause a violation of the Act, 105 CMR 120.000, and licenses or unnecessary exposure to radiation or radioactive material;**

(5) **Shall be instructed in the appropriate response to warnings made in the event of any unusual occurrence or malfunction that may involve exposure to radiation or radioactive material; and,**

(6) **Shall be advised as to the radiation exposure reports which workers shall be furnished pursuant to 105 CMR 120.754.**

(B) **The extent of these Actions shall be commensurate with potential radiological protection problems present in the workplace.**

120.754: Notifications and Reports to Individuals

(A) **Radiation exposure data for an individual and the results of any measurements, analyses, and calculations or radioactive material deposited or retained in the body of an individual shall be reported to the individual as specified in 105 CMR 120.754. The information reported shall include data and results obtained pursuant to 105 CMR 120.000, orders, or license conditions, as shown in records shall maintained by the licensee or registrant pursuant to 105 CMR 120.267. Each notification and report shall:**

(1) **Be in writing;**

(2) **Include appropriate identifying data such as the name of the licensee or registrant, the name of the individual, and the individual=s social security**

number;

(3) Include the individual=s exposure information; and

(4) Contain the following statement: A**This report is furnished to you under the provisions of 105 CMR 120.750. You should preserve this report for further reference.**@

(B) Each licensee or registrant shall furnish to each worker a written report of the worker=s exposure to radiation or radioactive material as shown in records maintained by the licensee or registrant pursuant to 105 CMR 120.267.

(C) Each licensee or registrant shall furnish a written report of the worker=s exposure to sources of radiation at the request of a worker, formerly engaged in activities controlled by the licensee or registrant. The report shall include the dose record for each year the worker was required to be monitored pursuant to 105 CMR 120.226. Such report shall be furnished within 30 days from the date of the request, or within 30 days after the dose of the individual has been determined by the licensee or registrant, whichever is later. The report shall cover the period of time that the worker=s activities involved exposure to sources or radiation and shall include the dates and locations of work under the license or registration in which the worker participated during this period.

(D) When a licensee or registrant pursuant to 105 CMR 120.282, 120.283, or 120.284 to report to the Agency any exposure of an individual to sources of radiation, the licensee or registrant shall also provide the individual a written report on the exposure data included therein. Such reports shall be transmitted at a time not later than the transmittal to the Agency.

(E) At the request of a worker who is terminating employment with the licensee or registrant in work involving exposure to radiation or radioactive material, during the current year, each licensee or registrant shall provide at termination of each such worker, or to the worker=s designee a written report regarding the radiation dose received by that worker from operations of the licensee or registrant during the current year or fraction thereof. If the most recent individual monitoring results are not available at that time, a written estimate of the dose shall be provided together with a clear indication that this is an estimate.

120.755: Presence of Representatives of Licensees or Registrants and Workers During Inspection

(A) Each licensee or registrant shall afford to the Agency at all reasonable times opportunity to inspect materials, machines, activities, facilities, premises, and records pursuant to 105 CMR 120.00

(B) During an inspection, Agency inspectors may consult privately with workers as specified in 105 CMR 120.756. The licensee or registrant may accompany inspectors during other phases of an inspection.

(C) **If, at the time of inspection, an individual has been authorized by the workers to represent them during Agency inspections, the licensee or registrant shall notify inspectors of such authorization and shall give the worker=s representative an opportunity to accompany the inspectors during the inspection of physical working conditions.**

(D) **Each workers= representative shall be routinely engaged in work under control of the licensee or registrant and shall have received instructions as specified in 105 CMR 120.753.**

(E) **Different representatives of licensees or registrants and workers may accompany the inspectors during different phases of an inspection if there is no resulting interference with the conduct of the inspection. However, only one workers= representative at a time may accompany the inspectors.**

(F) **With the approval of the licensees or registrant and the workers' representative, an individual who is not routinely engaged in work under control of the licensee or registrant, for example, a consultant to the licensee or registrant or to the workers= representative shall be afforded the opportunity to accompany Agency inspectors during the inspection of physical working conditions.**

(G) **Notwithstanding the other provisions of 105 CMR 120.755, Agency inspectors are authorized to refuse to permit accompaniment by any individual who deliberately interferes with a fair and orderly inspection. With regard to areas containing information classified by an agency of the U.S. Government in the interest of national security, an individual who accompanies an inspector may have access to such information only if authorized to do so. With regard to any area containing proprietary information, the workers= representative for that area shall be an individual previously authorized by the licensee or registrant to enter that area.**

120.756: Consultation with Workers During Inspection

(A) **Agency inspectors may consult privately with workers concerning matters of occupational radiation protection and other maters related to applicable provisions of 105 CMR 120.000 and licensees to the extent the inspectors deem necessary for the conduct of an effective and thorough inspection.**

(B) **During the course of an inspection, any worker may bring privately to the attention of the inspectors, either orally or in writing, any past or present condition which the worker has reason to believe may have contributed to or caused any violation of M.G.L. c. I I 1, '', 5N, and 5P, 105 CMR 120.000, or license condition, or any unnecessary exposure of an individual to sources of radiation under the licensee's or registrant's control. Any such notice in writing shall comply with the requirements of 105 CMR 120.75 7(A).**

(C) **The provisions of 105 CMR 120.756(B) shall not be interpreted as authorization to disregard instructions pursuant to 105 CMR 120.753.**

120.757: Requests by Workers for Inspections

(A) **Any worker or representative of workers believing that a violation of the Act, 105 CMR 120.000, or license conditions exist or has occurred in work under a license or registration with regard to radiological working conditions in which the worker is engaged may request an inspection by giving notice of the alleged violation to the Agency. Any such notice shall be in writing, shall set forth the specific grounds for the notice, and shall be signed by the worker or representative of the workers. A copy shall be provided to the licensee or registrant by the Agency no later than at the time of inspection except that, upon the request of the worker giving such notice, his name and the name of individuals referred to therein shall not appear in such copy or on any record published, released, or made available by the Agency, except for good cause shown.**

(B) **If, upon receipt of such notice, the Agency determines that the complaint meets the requirements set forth in 105 CMR 120.757(A), and that there are reasonable grounds to believe that the alleged violation exists or has occurred, an inspection shall be made as soon as practicable to determine if such alleged violation exists or has occurred. Inspections pursuant to 105 CMR 120.757 need not be limited to matters referred to in the complaint.**

(C) **No licensee, registrant, or contractor or subcontractor of a licensee or registrant shall discharge or in any manner discriminate against any work because such worker has filed any complaint or instituted or caused to be instituted any proceeding under 105 CMR 120.000 or has testified or is about to testify in any such proceeding or because of the exercise by such worker on behalf of himself or others of any option afforded by 105 CMR 120.750.**

120.758: Inspections Not Warranted : Informal Review

(A)(1) **If the Agency determines with respect to a complaint under 105 CMR 120.757, that an inspection is not warranted because there are no reasonable grounds to believe that a violation exists or has occurred, the Agency shall notify the complainant in writing of such determination. The complainant may obtain review of such determination by submitting a written statement of position with the Department. The Department will provide the licensee or registrant with a copy of such statement by certified mail, excluding, at the request of the complainant the name of the complainant. The licensee or registrant may submit an opposing written statement of position with the Department. The Department will provide the complainant with a copy of such statement by certified mail.**

(A)(2) **Upon the request of the complainant, the Department may hold an informal conference in which the complainant and the licensee or registrant may, orally present their views. An informal conference may also be held at the request of the licensee or registrant, but disclosure of the identity of the complainant will be made only following receipt of written authorization from the complainant. After considering all written and oral views presented, the Department shall affirm modify, or reverse the determination of**

the Agency and furnish the complainant and the licensee or registrant a written notification of the decision and the reason therefore.

(B) **If the Agency determines that an inspection in not warranted because the requirements of 105 CMR 120.757(A) have not been met, the complainant shall be notified in writing of such determination. Such determination shall be without prejudice to the filing of a new complaint meeting the requirement.**