

**Massachusetts Institute of Technology
Radiation Protection Program**

**Analytical X-Ray Equipment
Safety Program**

Second Edition
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Approval by the RPC _____ on _____
Radiation Protection Officer

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The M.I.T. Radiation Protection Committee 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 the radiation protection regulations promulgated by the state, Federal, and local agencies for both ionizing and non-ionizing radiation producing equipment, RF generators, and lasers must be registered with the M.I.T. Radiation Protection Program.

If you have any questions concerning x-ray safety, please contact the M.I.T. Radiation Protection Program - Building N52-496, ext. 2-3477.

ACKNOWLEDGMENT : Information has been incorporated into this safety guide from the following documents: ANSI-N43.2-1977 "Radiation Safety for X-Ray Diffraction and Fluorescence Analysis Equipment", 105 CMR 120.600 "Radiation Safety Requirements for Analytical X-Ray Equipment", and 105 CMR 120.200 "Standards for Protection Against Radiation".

A copy of these documents is on file at the M.I.T. Radiation Protection Program, N52-496.

1.0 Purpose

Analytical x-ray equipment is used for x-ray diffraction analysis, fluorescence analysis, or direct x-ray transmission analysis of materials. These analytical x-ray systems are comprised of components that utilize x-rays to determine elemental composition, or to examine the microstructure of materials. These analytical x-ray devices are used for nonmedical purposes.

The primary objective of this program is to keep occupational exposures to radiation as low as reasonably achievable (ALARA) while utilizing these types of equipment. This safety program establishes M.I.T. procedures for the safe operation of analytical x-ray equipment and the associated potential radiation hazards.

2.0 Scope and Application

Analytical x-ray equipment has become a major tool in research and quality control programs. Despite the advances in operating techniques and equipment design, the most common hazards are due to operator errors and equipment malfunctions. The potential exposures to the primary beam is of a major concern when evaluating potential radiation exposures. Exposures to the primary beam in a typical analytical x-ray unit may be as great as 100,000 R/min.

This program applies to all departments, supervisors, employees, students, visiting scientists, and any personnel from other organizations whose work involves the use of analytical x-ray equipment at M.I.T. Operational procedures will be established for each x-ray unit to maintain radiation exposures as low as reasonably achievable (ALARA) with due considerations as to the feasibility and nature of the research being conducted.

3.0 Radiation Protection Program Services

The M.I.T. Radiation Protection Program provides services to assist departments, supervisors, students and technicians in maintaining a comprehensive analytical x-ray equipment safety program.

The services provided include the following:

1. Provide training and instruction in the safety procedures and practices required for all persons who work with or near analytical x-ray equipment.
2. Maintain a current listing of analytical x-ray equipment and its authorized users.
3. Evaluate each installation as to the control of radiation exposures including recommendations for placement of radiation warning signs and/or warning devices.
4. Perform routine annual radiation safety inspections of analytical x-ray equipment.
5. Review and approve modifications to x-ray apparatus that affects radiation protection including: x-ray tube housing, cameras, shielding, and safety interlocks.
6. Provide personnel monitoring badges and area monitors.
7. Investigate any unusual radiation exposures to personnel and take remedial action if necessary.
8. Assist in achieving compliance with all applicable federal, state, and local rules and regulations.
9. Register x-ray units with the Massachusetts Department of Public Health as per section 105 CMR 120.600.

4.0 Analytical X-Ray Equipment

4.1. Supervisors' Responsibilities

Each analytical x-ray equipment project supervisor will be responsible for:

1. Providing the Radiation Protection Program with a completed RPO-81 form describing the proposed use of the equipment. The Radiation Protection Program will review each proposed installation and operating procedures. Approval from the Radiation Protection Committee must be secured before the x-ray equipment is operated.
2. All operations carried out with the equipment.
3. Ensuring that all personnel under their supervision are registered with and receive general training from the Radiation Protection Program in the safe use of analytical x-ray equipment.

4. Compliance with the specific recommendations made by the Radiation Protection Program, and also the general equipment and safety requirements listed in Section 5.
5. Ensuring that only authorized users will enter the areas that are restricted due to the use of the analytical x-ray equipment.
6. Providing specific hands-on training to the authorized users for each analytical x-ray unit.
7. Ensuring that the project has a properly operating survey instrument.

4.2 Users' Responsibilities

Each authorized user of the analytical x-ray equipment is responsible for:

1. Wearing the assigned personnel monitoring badge(s) as required.
2. Performing area monitoring of the x-ray unit set-up when the beam is energized.
3. Notifying the Radiation Protection Program when:
 - a. it is necessary to alter safety devices, such as bypassing interlocks. The exception would be generic bypassing for test purposes that has been authorized by the Radiation Protection Program.
 - b. it is known or suspected that a radiation exposure of personnel may have occurred.
 - c. an existing unit is moved or beam path is altered.
 - d. there are changes in operating parameters such as kV and mA beyond that which were approved by the Radiation Protection Program previously.
 - e. there are changes in the approved shielding arrangement.
 - f. there is any major service performed on the x-ray unit.

5.0 General Equipment and Safety Requirements

1. The entrance(s) to any area that is restricted for radiation protection purposes will be posted with a sign bearing the radiation symbol and the words, "CAUTION RADIATION - THIS AREA CONTAINS EQUIPMENT WHICH PRODUCES X-RAYS WHEN ENERGIZED - TO BE OPERATED ONLY BY QUALIFIED PERSONNEL."
2. The x-ray unit switch that energizes the x-ray tube should be posted with a sign bearing the radiation symbol and the words, "CAUTION RADIATION - THIS EQUIPMENT PRODUCES RADIATION WHEN ENERGIZED - TO BE OPERATED ONLY BY QUALIFIED PERSONNEL."
3. Unused ports on radiation source housing will be secured in a closed position in a manner which prevents casual opening.

4. Before energizing the x-ray tube, all ports will be closed or fitted with an approved apparatus.
5. Each x-ray unit shall have a fail-safe warning light to indicate when the x-ray tube is energized. The light will be located near the x-ray port and will be energized by the same switch that turns the beam on. The light shall either function as a fuse, or the light will be equipped with a twin-bulb redundancy.
6. The analytical x-ray equipment should be placed in a separate room from other work areas whenever practical.
7. Properly installed permanent shields should be used in preference to temporary shielding. When temporary shielding is necessary, it must be securely fastened.
8. Set-up procedures will be carried out with the x-ray beam off or with shutters closed as much as possible. If the latter, a survey shall be performed before starting set-up.
9. All safety devices such as interlocks, shutters, warning light, etc. will be tested weekly or upon each use (if use is less frequent) to ensure proper operation.
10. Safety interlocks will not be routinely used to deactivate the x-ray beam.
11. The unit will be positioned so that the primary x-ray beam is completely attenuated by the beam catcher. If this is not possible for an experimental set-up, or if the accessible scatter dose rate to personnel exceeds 2.0 mR/hr, then either the entire unit will be shielded, or entry to the room must be restricted. The room must be locked and appropriately posted with "CAUTION - RADIATION AREA".
12. Each x-ray tube housing will be constructed such that with all shutters closed, the leakage radiation measured at 5 cm from its surface does not exceed 2.5 mR/hr at any tube rating.
13. Each generator should be checked for x-ray generation in its electronic components and, if necessary, supplied with a protection cabinet which limits the leakage radiation at a distance of 5cm from its surface to a dose rate of not more than 0.25 mR/hr.
14. When necessary, shutter status indication (open or closed) should be provided on or adjacent to the tube housing which will automatically indicate the position of each shutter in a readily discernible manner.
15. For OPEN BEAM x-ray equipment the following precautions apply:
 - a. the unit must have visible flashing lights that operate ONLY WHEN the primary beam is energized. This signal should be labeled with words such as "X-RAY ON" so that its purpose is easily identified.

- b. the analytical x-ray equipment user should be in immediate attendance at all times when the equipment is in operation unless otherwise approved by the Radiation Protection Program.
- c. when not in operation, the equipment will be secured in such a way as to be accessible to or operable by analytical x-ray equipment users only (i.e. keylocks).
- d. Whenever practicable, all shutters should be provided with a “shutter open” indication of fail-safe design.

Note: Open beam techniques should only be used after all attempts at an enclosed system have proven this to be impracticable.

- 16. Particular attention should be given to viewing devices to ensure that lenses and other transparent components attenuate the radiation beam to minimal levels when alignment involves working near the open primary beam. The beam current should be reduced when a fluorescent alignment tool is used; dimming the room light will permit a significant reduction in beam current. The fluorescent alignment tool should be long enough to permit the analytical x-ray equipment user’s hand to be kept a safe distance from the beam.

The Radiation Protection Program can be consulted for more detailed advice.

6.0 Radiation Surveys

Analytical x-ray equipment USERS are required to make the following surveys with a G.M. survey meter:

- 1. Radiation survey will be performed prior to each new use of the x-ray equipment.
- 2. Weekly surveys should be performed to ensure radiation levels have not changed.
- 3. Periodic surveys should be performed on the local components to check for leakage radiation when the set-up is changed.

The RADIATION PROTECTION PROGRAM will make surveys according to the following guidelines:

- 1. Upon the installation of the x-ray equipment and at least once a year thereafter.
- 2. Upon any change in the initial arrangement, number, or type of local components in the system.
- 3. Upon any maintenance requiring the disassembly or removal of a local component in the system.

7.0 Personnel Monitoring

- 1. The analytical x-ray equipment users will wear whole body and/or wrist or finger badges assigned by the Radiation Protection Program. The monitoring device should be worn such that the body part nearest the primary beam is monitored.

Monitoring badges worn on the chest or abdomen may provide an indication as to the amount of stray radiation to the whole body.

2. Operations involving the use of analytical x-ray equipment will be planned so that the exposures are in compliance with the limits in Table I.

Table I MIT Annual Limits for Radiation Dose

Area Exposed	Amount (mrems/year)
Total Effective Whole Body Dose Equivalent ¹ (TEDE)	5000
Skin of whole body and extremities ²	50000
Lens of the Eye	15000
Declared Pregnant Worker ³	500

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 A: Definitions

ANALYTICAL X-RAY EQUIPMENT: Any device which uses x-rays for the purpose of examining the microstructure of materials. This includes all types of x-ray diffraction and spectrographic equipment.

ANALYTICAL X-RAY SYSTEM: A group of components which x-rays to determine the elemental composition or to examine the microstructure of materials.

ANODE: A positive electrode; in an x-ray tube, it is the target for the accelerated electrons.

CATHODE: A negative electrode; it is the filament at which free electrons are produced by thermionic emission.

CONTROLLED AREA: A specified area in which exposure of personnel to radiation or radioactive material is controlled and which is under the supervision of a person who has knowledge of the appropriate radiation protection practices, including pertinent regulations. The dose equivalent may exceed 500 mrem in any year but shall not exceed 2 mrem in any one hour or 100 mrem in any 7 consecutive days.

DOSE, ABSORBED (RAD): The amount of energy deposited in medium by a beam of ionizing radiation. The special unit of absorbed dose is the RAD which is equal to 100 ergs/gm or 0.01 joule/kilogram.

DOSE EQUIVALENT (REM): A quantity that expresses the irradiation incurred by exposed persons on a common scale for all radiations. It is defined numerically as the product of the absorbed dose in rads multiplied by the quality factor and other certain modifying factors. The unit of dose equivalent is the REM. (For radiation protection purposes in this safety program, the dose equivalent in rems may be considered numerically equivalent to the absorbed dose in rads and exposure in roentgens.)

EXPOSURE (ROENTGEN): A measure of the ionization produced in air by x or gamma radiation. This special unit of exposure is the roentgen which is equal to $2.58E-4$ coulomb of charge collected per kilogram of air exposed.

FAIL-SAFE DESIGN: One in which all failures of indicator or safety components that can reasonably be anticipated cause the equipment to fail in a mode such that personnel are safe from exposure to radiation. For example: (a) if a light indicating "X-RAY ON" fails, the production of x-rays shall be prevented, and (b) if a shutter status indicator fails, the shutter shall close.

HALF VALUE LAYER (HVL): the thickness of any material that is required to reduce the intensity of a given beam by one half.

INSTALLATION ENCLOSURE: That portion of an x-ray installation which clearly defines the transition from a noncontrolled area to a controlled area, and provides such shielding as may be required to limit the dose rate in noncontrolled areas during normal operation.

INTERLOCK: A device for precluding access to an area in which radiation is present by automatically reducing the exposure rate upon entry by personnel or parts of their body.

kVp (KILOVOLTAGE PEAK): The maximum potential difference applied between the anode and cathode by a pulsating voltage generator.

LEAKAGE RADIATION: All radiation coming from within the x-ray tube housing except the primary radiation beam.

LOCAL COMPONENT: Part of an analytical x-ray system that includes areas that are struck by x-rays such as radiation source housing, port and shutter assemblies, collimator, sample holders, cameras, goniometers, detectors and shielding, but do not include power supplies, transformers, amplifiers, readout devices, and control panels.

mAs (MILLIAMPERE SECONDS): A combination unit which is the product of the tube current (expressed in mA) and the exposure time (expressed in seconds). The total output of an x-ray tube is directly proportional to the mAs (or either of its components).

MAXIMUM PERMISSIBLE DOSE EQUIVALENT: The maximum dose equivalent that a person or specified parts thereof shall be allowed to receive in a stated period of time. The limits are listed in Table I.

NONCONTROLLED AREA: Operation under conditions suitable for collecting data as recommended by a manufacturer of the x-ray system. Recommended shielding and barriers shall be in place. The dose equivalent shall not exceed 100 mrem/year.

NORMAL OPERATION: Operation under conditions suitable for collecting data recommended by a manufacturer of the x-ray system. Recommended shielding and barriers shall be in place.

OPEN-BEAM CONFIGURATION: An analytical x-ray system in which individual could accidentally place some part of their body in the primary beam path during normal operation.

PRIMARY BEAM: Radiation which passes through an aperture of the source housing by a direct path from either the x-ray tube or a radioactive source located in the radiation source housing which is either unscattered or undeflected.

RADIATION AREA: Any area accessible to personnel in which there exists radiation at such levels that a major portion of the body (whole body, head and trunk, active blood-forming organs, gonads, or eye lenses) could receive in any one hour a dose equivalent in excess of 5 mrem, or in 5 consecutive days a dose equivalent in excess of 100 mrem.

SCATTERED RADIATION: Radiation that, during passage through matter, has been deviated in direction.

STRAY RADIATION: The sum of leakage and scattered radiation.

SYSTEM BARRIER: That portion of an x-ray installation which clearly defines the transition from a controlled area to a radiation area and provides such shielding as may be required to limit the dose rate in the controlled areas during normal operations.

THERMIONIC EMISSION: The process by which free electrons are produced at the cathode of an x-ray tube when the filament is electrically heated such that the thermal energy imparted to the electrons is sufficient to overcome the forces binding them to the filament.

TUBE HOUSING-APPARATUS COMPLEX: Those parts of an analytical x-ray device in which x-rays are produced and utilized. This includes the x-ray tube housing, shutter or port assemblies, collimator, cameras, goniometers, and electronic radiation detectors. This is not intended to include such components as transformers, control panels, or temporary shielding.

X-RAY GENERATOR: That portion of an x-ray system which provides the accelerating voltage and current for the x-ray tube.

X-RAY DIFFRACTION EQUIPMENT: An analytical x-ray device in which an x-ray beam (usually monochromatic) is made to strike a specimen, causing a portion of the beam to be diffracted. Measurements of certain parameters of the diffracted beam may be used to provide qualitative and/or quantitative information about the specimen.

X-RAY FLUORESCENCE EQUIPMENT: An analytical x-ray device in which a polychromatic x-ray beam is made to strike a specimen, producing x-ray fluorescence which is characteristic of the specimen. A portion of the fluorescent radiation is directed into an analyzing crystal where it is diffracted. The wavelength of interest may then be monitored by a properly positioned detector to produce qualitative and/or quantitative analysis of the specimen.

APPENDIX B: Regulatory Guide 8.13, “Instruction Concerning Prenatal Radiation Exposure”

http://www.saic.com/home/nrc_rad/reg_gds.htm

APPENDIX C: Regulatory Guide 8.29, “Instruction Concerning Risks From Radiation Exposure”

http://www.saic.com/home/nrc_rad/reg_gds.htm

APPENDIX D
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 from 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.

**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 E

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 far below 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 RPO 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 RPO for enforcement of the ALARA concept.
- (2) The RPC will support the RPO when it is necessary for the RPO 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 RPO will present an annual summary of exposure levels to the RPC.

Table 1
Investigational Levels

	<u>(mrem/calendar quarter)</u>	
	<u>Level I</u>	<u>Level II</u>
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 RPO 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 RPO will review radiation surveys in restricted, controlled and uncontrolled 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 RPO 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 RPO 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 RPO will work closely with all projects and workers in order to develop ALARA procedures for working with radioactive materials.
- (2) The RPO 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 RPO will investigate all known instances of deviation from good ALARA practices and, if possible, will determine the causes. When the cause is known, the RPO 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 occupation 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 RPO 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 RPO will review and record on Form NRC-5, "Current Occupational External Radiation Exposures," or an equivalent form (e.g., R.S. Landauer dosimeter processor'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 RPO 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 RPO 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 F
Commonwealth of Massachusetts Regulations

105 CMR 120.600: RADIATION SAFETY REQUIREMENTS FOR ANALYTICAL X-RAY EQUIPMENT

120.601: Purpose and Scope

105 CMR 120.600 provides special requirements for analytical x-ray equipment. The requirements of 105 CMR 120.600 are in addition to, and not in substitution for, applicable requirements in other Sections of 105 CMR 120.000.

120.602: Definitions

As used in 105 CMR 120.600, the following definitions apply:

Analytical X-Ray Equipment means equipment used for x-ray diffraction or fluorescence analysis.

Analytical X-Ray System means a group of components utilizing x or gamma rays to determine the elemental composition or to examine the microstructure of materials.

Fail-Safe Characteristics mean a design feature which causes beam port shutters to close, or otherwise prevents emergence of the primary beam, upon the failure of a safety or warning device.

Local Components mean part of an analytical x-ray system and include areas that are struck by x-rays such as radiation source housings, port and shutter assemblies, collimators, sample holders, cameras, goniometers, detectors, and shielding, but do not include power supplies, transformers, amplifiers, readout devices, and control panels.

Normal Operating Procedures mean step-by-step instructions necessary to accomplish the analysis. These procedures shall include sample insertion and manipulation, equipment alignment, routine maintenance by the registrant [or licensee], and data recording procedures, which are related to radiation safety.

Open-Beam Configuration means an analytical x-ray system in which an individual could accidentally place some part of his body in the primary beam path during normal operation.

Primary Beam means radiation which passes through an aperture of the source housing by a direct path from the x-ray tube or a radioactive source located in the radiation source housing.

120.603: Equipment Requirements

(A) Safety Device. A device which prevents the entry of any portion of an individual's body into the primary x-ray beam path or which causes the beam to be shut off upon entry into its path shall be provided on all open-beam configurations. A registrant [or licensee] may apply to the Agency for an exemption from the requirement of a safety device. Such application shall include:

(1) A description of the various safety devices that have been evaluated;

- (2) The reason each of these devices cannot be used; and,
- (3) A description of the alternative methods that will be employed to minimize the possibility of an accidental exposure, including procedures to assure that operators and others in the area will be informed of the absence of safety devices.

(B) Warning Devices.

- (1) Open-beam configurations shall be provided with a readily discernible indication of:
 - (a) X-ray tube "on-off" status located near the radiation source housing, if the primary beam is controlled in this manner; and/or,
 - (b) Shutter "open-closed" status located near each port on the radiation source housing, if the primary beam is controlled in this manner.
- (2) Warning devices shall be labeled so that their purpose is easily identified. On equipment installed after the effective date of 105 CMR 120.600, warning devices shall have fail-safe characteristics.

(C) Ports. Unused ports on radiation source housings shall be secured in the closed position in a manner which will prevent casual opening.

(D) Labeling. All analytical x-ray equipment shall be labeled with a readily discernible sign or signs bearing the radiation symbol and the words:

- (1) "CAUTION - HIGH INTENSITY X-RAY BEAM", or words having a similar intent, on the x-ray source housing; and,
- (2) "CAUTION RADIATION - THIS EQUIPMENT PRODUCES RADIATION WHEN ENERGIZED", or words having a similar intent, near any switch that energizes an x-ray tube if the radiation source is an x-ray tube; or,
- (3) "CAUTION - RADIOACTIVE MATERIAL", or words having a similar intent, on the source housing in accordance with 105 CMR 120.223 if the radiation source is a radionuclide.

(E) Shutters. On open-beam configurations installed after the effective date of 105 CMR 120.600, each port on the radiation source housing shall be equipped with a shutter that cannot be opened unless a collimator or a coupling has been connected to the port.

(F) Warning Lights.

- (1) An easily visible warning light labeled with the words "X RAY ON", or words having a similar intent, shall be located:
 - (a) Near any switch that energizes an x-ray tube and shall be illuminated only when the tube is energized; or,
 - (b) In the case of a radioactive source, near any switch that opens a housing shutter and shall be illuminated only when the shutter is open.
- (2) On equipment installed after the effective date of 105 CMR 120.600, warning lights shall have fail-safe characteristics.

(G) Radiation Source Housing. Each radiation source housing shall be subject to the following requirements:

- (1) Each x-ray tube housing shall be equipped with an interlock that shuts off the tube if it is removed from the radiation source housing or if the housing is disassembled.
- (2) Each radioactive source housing or port cover or each x-ray tube housing shall be so constructed that, with all shutters closed, the radiation measured at a distance of five centimeters from its surface is not capable of producing a dose in

excess of 2.5 millirems (0.025 mSv) in one hour. For systems utilizing x-ray tubes, this limit shall be met at any specified tube rating.

(H) Generator Cabinet. Each x-ray generator shall be supplied with a protective cabinet which limits leakage radiation measured at a distance of five centimeters from its surface such that it is not capable of producing a dose in excess of 0.25 millirem (2.5 μ Sv) in one hour.

120.604: Area Requirements

(A) Radiation Levels. The local components of an analytical x-ray system shall be located and arranged and shall include sufficient shielding or access control such that no radiation levels exist in any area surrounding the local component group which could result in a dose to an individual present therein in excess of the dose limits given in 105 CMR 120.206. For systems utilizing x-ray tubes, these levels shall be met at any specified tube rating.

(B) Surveys.

(1) Radiation surveys, as required by 105 CMR 120.221, of all analytical x-ray systems sufficient to show compliance with 105 CMR 120.604(A) shall be performed:

- (a) Upon installation of the equipment, and at least once every 12 months thereafter;
- (b) Following any change in the initial arrangement, number, or type of local components in the system;
- (c) Following any maintenance requiring the disassembly or removal of a local component in the system;
- (d) During the performance of maintenance and alignment procedures if the procedures require the presence of a primary x-ray beam when any local component in the system is disassembled or removed;
- (e) Any time a visual inspection of the local components in the system reveals an abnormal condition; and,
- (f) Whenever personnel monitoring devices show a significant increase over the previous monitoring period or the readings are approaching the limits specified in 105 CMR 120.202.

(2) Radiation survey measurements shall not be required if a registrant [or licensee] can demonstrate compliance with 105 CMR 120.604(A) to the satisfaction of the Agency.

(C) Posting. Each area or room containing analytical x-ray equipment shall be conspicuously posted with a sign or signs bearing the radiation symbol and the words "CAUTION - X-RAY EQUIPMENT" or words having a similar intent in accordance with 105 CMR 120.223.

120.605: Operating Requirements

(A) Procedures. Normal operating procedures shall be written and available to all analytical x-ray equipment workers. No individual shall be permitted to operate analytical x-ray equipment in any manner other than that specified in the procedures unless such individual has obtained written approval of the radiation safety officer.

(B) Bypassing. No individual shall bypass a safety device or interlock unless such individual has obtained the approval of the radiation safety officer. Such approval shall

be for a specified period of time. When a safety device or interlock has been bypassed, a readily discernible sign bearing the words "SAFETY DEVICE NOT WORKING", or words having a similar intent, shall be placed on the radiation source housing.

(C) Repair or Modification of X-Ray Tube Systems. Except as specified in H.5(B), no operation involving removal of covers, shielding materials or tube housings or modifications to shutters, collimators, or beam stops shall be performed without ascertaining that the tube is off and will remain off until safe conditions have been restored. The main switch, rather than interlocks, shall be used for routine shutdown in preparation for repairs.

(D) Radioactive Source Replacement, Testing, or Repair. Radioactive source housings shall be opened for source replacement, leak testing, or other maintenance or repair procedures only by individuals authorized to specifically conduct such procedures under a license issued by the U.S. Nuclear Regulatory Commission, an Agreement State, or a Licensing State.

120.606: Personnel Requirements

(A) Instruction. No individual shall be permitted to operate or maintain analytical x-ray equipment unless such individual has received instruction in and demonstrated competence as to:

- (1) Identification of radiation hazards associated with the use of the equipment;
- (2) Significance of the various radiation warning, safety devices, and interlocks incorporated into the equipment, or the reasons they have not been installed on certain pieces of equipment and the extra precautions required in such cases;
- (3) Proper operating procedures for the equipment;
- (4) Recognition of symptoms of an acute localized exposure; and,
- (5) Proper procedures for reporting an actual or suspected exposure.

(B) Personnel Monitoring.

- (1) Finger or wrist dosimetric devices shall be provided to and shall be used by:
 - (a) Analytical x-ray equipment workers using systems having an open-beam configuration and not equipped with a safety device; and,
 - (b) Personnel maintaining analytical x-ray equipment if the maintenance procedures require the presence of a primary x-ray beam when any local component in the analytical x-ray system is disassembled or removed.
- (2) Reported dose values shall not be used for the purpose of determining compliance with 105 CMR 120.200 unless evaluated by a qualified expert.

APPENDIX G
Commonwealth of Massachusetts Regulations

105 CMR 120.750: NOTICES, INSTRUCTIONS, AND REPORTS TO WORKERS;
INSPECTIONS

120.751: Purpose and Scope

105 CMR 120.750 establishes 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. 111, §§ 3, 5M, 5N, 5O, and 5P and regulations, orders, and licenses issued thereunder regarding radiological working conditions. 105 CMR 120.750 applies 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 and in 105 CMR 120.200;
 - (2) The license, certificate 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 order issued pursuant to 105 CMR 120.001, and any response from the licensee or registrant.
- (B) If posting of 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 "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 registrant's 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 until 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 registrant's workplace;
 - (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 instructions shall be commensurate with potential radiological health 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 of 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 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:
"This report is furnished to you under the provisions of 105 CMR 120.750. You should preserve this report for future reference."

(B) Each licensee or registrant shall furnish to each worker annually 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 of 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 is required 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 the 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 to 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 120.000.

(B) During an inspection, Agency inspectors may consult privately with workers as specified in 105 CMR 120.756. The licensee or registrant may accompany Agency 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 the inspectors of such authorization and shall give the workers' 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 licensee 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 Inspections

(A) Agency inspectors may consult privately with workers concerning matters of occupational radiation protection and other matters related to applicable provisions of 105 CMR 120.000 and licenses 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. 111, §§, 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 120.757(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 exists 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 worker 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.

(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 therefor.

(B) If the Agency determines that an inspection is 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 requirements of 105 CMR 120.757(A).

120.760: Emergency Plans

The user should formulate suitable emergency plans as may be indicated to protect his employees and the public against potential hazards due to his specific source(s), and should make known the details and existence of such plans to the Agency and such other public agencies having a concern; including, but not limited to, boards of health, fire departments and police departments.