RADIATION SAFETY MANUAL

U.S. ENVIRONMENTAL PROTECTION AGENCY

CINCINNATI, OHIO

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EMERGENCY PROCEDURES FOR RADIATION ACCIDENTS

1. Survey and then evacuate possible exposed personnel from accident area and give urgent first aid.

2. Notify: Medical — Telephone: FTS 684-7283, Coml. 569-7283

   Health Physics — Telephone: FTS 684-7269, Coml. 569-7269

   Your Laboratory Supervisor — Telephone: _____

3. Limit entry into radiation area. Turn off utilities as necessary to control emissions.

4. Confine and survey all contaminated people. Give first aid for traumatic injury and burns.

5. Evaluate situation in regard to contamination with radioactive materials and the level and type of radiation exposure.

6. Perform simple decontamination and resurvey personnel involved, if contamination is present.

7. Save all samples of clothes, jewelry, blood, urine stool and vomitus. Label each with name, time, and date.

8. Obtain careful history of accident.

9. Send personnel to University of Cincinnati Hospital if exposure of 100 R or more is suspected.

10. Obtain names, addresses, and telephone numbers of all witnesses.

IN CASE OF SUSPECTED OR ACTUAL EMERGENCY

CALL

Your Supervisor _____ Telephone: Day_____ Coml._____ Night_____

AND

Radiation Safety Officer
William R. Burg, Ph.D. Telephone: FTS: 684-7269, Coml. 569-7269, Home: 922-4129

AND

Deputy Radiation Safety Officer
Carl T. Rybak Telephone: FTS: 684-7457, Coml. 569-7457, Home: 271-9229

AND

Chairman, Radiation Safety Committee
Louis W. Lefke

Telephone: Day FTS 684-7953
Coml. 569-7953
Night 231-0806

If no answer, call other persons listed in Appendix A, pages 35 and 37.

INTRODUCTION

This radiation manual is designed to facilitate the safe use of radioactive sources of all types within the Andrew W. Breidenbach Environmental Research Center and other associated Environmental Protection Laboratories located at 3411 Church Street, Newtown, Ohio; 5995 Center Hill Road, Cincinnati, Ohio; and 1600 Gest Street, Cincinnati, Ohio. The Radiation Safety Committee is charged with the responsibility of radiation safety for investigators, technicians, students, maintenance personnel, supporting staff, and the general public. It is not concerned with the quality of scientific work.

It is the expectation of our Committee that this manual will aid and encourage the safe use of radiation as a method of research and training. The members of the Committee and the Radiation Safety Officer are available for help and consultation at any time. If certain regulations seem restrictive, one should realize that these requirements are dictated by considerations of health and safety and by the rules of the Nuclear Regulatory Commission (NRC), State of Ohio and City of Cincinnati. We are proud (of the fact) that we possess a broad general license from the NRC for the use of radionuclides which permits the AWBERC to obtain almost all radionuclides quickly. All of us bear equal responsibility for the operation of a safe program so that our broad license can continue.

Any individual planning to work with radionuclides under the broad license of the AWBERC is required to submit the form "Certification for Use of Radiation" before beginning work (see Appendix J for sample form) to insure he or she has adequate training and experience with radionuclides.

Each user of radiation is required to read this manual and be familiar with its contents according to the U.S. Code of Federal Regulations (10 CFR 20). Each principal investigator shall have access to a copy of NUREG 0426 Conditions And Limitations On The General Provisions of 10 CFR 150.20. He and his staff shall be responsible for the relevant contents of this document. The users include the principal investigator or responsible person and all other persons working with radiation.

This manual includes definitions of SI units of radiation activity and exposure. They may be found in Appendix B. The use of these units, which are part of the International System for measurement of physical properties, has been adopted by the International Commission on Radiological Protection (ICRP) and will be found throughout the manual. Nevertheless the use of the R, rad and rem will be used since most instruments still utilize these units on their scales.

The words "shall" and "should" are used extensively throughout this manual. Please note these definitions: 1) shall - denotes that the ensuing recommendation is necessary or essential to meet the currently accepted standards of

recommendations that are to be applied when practicable in the interest of reducing radiation exposure.

Questions relating to the policies and regulations in this manual can be discussed by calling Dr. William Burg at FTS 684-7269/Coml. 569-7269.

Louis W. Lefke, Chairman
Radiation Safety Committee

RADIATION SAFETY MANUAL

ANDREW W. BREIDENBACH ENVIRONMENTAL RESEARCH CENTER

I. RESPONSIBILITY

A. Radiation Safety Committee (RSC)

The Radiation Safety Committee is responsible for the control of all radionuclides and radiation safety at the AWBERC and other associated Environmental Protection Agency laboratories in the Cincinnati area. The RSC is responsible for the administration of the license from the U.S. Nuclear Regulatory Commission (NRC) for the use of radionuclides and for all other radioactive materials and devices which emit ionizing radiation in the AWBERC. The RSC shall designate a responsible Radiation Safety Officer (RSO) for all operations involving sources of ionizing radiation. Members of the RSC are listed in Appendix A.

Applications for routine uses of radionuclides are approved by the Chairman, Program Safety Officer, PSO and RSO. These applications are then included in the agenda for the next quarterly RSC meeting for committee discussion and final approval. All new uses of radionuclides must be presented by application to the RSC and require unanimous approval by members present. Meetings of the RSC are held quarterly. Other meetings can be held on petition of any member of the Committee.

The interim business of the RSC shall be conducted by the Chairman or the RSO and shall be subject to the eventual approval of the Committee. In the absence of these two individuals, those persons deputized (see Appendix A) may serve in their place.

1. Responsibilities of the Radiation Safety Committee (RSC)

a. Review and approve or disapprove applications for the use of radionuclides within the AWBERC and keep records of such actions.

b. Prescribe special conditions that may be necessary for the safe handling of radionuclides, including additional training, designations of limited areas of use, proper disposal methods, and procedures to be.

followed for spills or other radiation accidents.

c. Receive and review periodic and/or urgent reports of the RSO regarding:

1. Results of area monitoring
2. Personnel exposures as measured by suitable dosimeters
3. Accidents in handling, storage, or use of radionuclides
4. Records of radionuclide procurement and disposal

d. Take remedial action if safe procedures are not being practiced where an ionizing radiation hazard exists or if these procedures are not in compliance with NRC regulations.

e. Keep Laboratory Directors and radionuclide users advised of current rules and recommendations of the various government agencies concerned with radiation protection and the safe use of radionuclides.

B. Radiation Safety Officer (RSO) or Deputy Radiation Safety Officer (DRSO)

Whenever the Radiation Safety Officer or RSO is mentioned in this manual, it is assumed to mean the Radiation Safety Officer or his designate.

The RSO will be responsible to the RSC for:

1. Compiling and disseminating information on radiation safety and health physics to users.

2. Consulting with users of ionizing radiation and giving advice concerning radiological safety.

3. Preparing all NRC license applications and state and municipal registrations for the AWBERC.

4. Reviewing all proposals for uses of ionizing radiation including radionuclides and external sources of radiation, e.g., X-rays, accelerators, etc.

5. Ordering, receiving and recording all radionuclides and maintaining all records pertinent thereto.

6. Maintaining personnel exposure records and providing personnel and area monitoring, including film badge service.

7. Suspending immediately any operation causing a significant radiation hazard.

8. Performing routine and special radiation surveys as deemed necessary for radiation safety.

9. Approving construction and remodeling of all facilities intended for radionuclide or other ionizing radiation use.

10. Supervising disposal of all radioactive waste.

11. Administering the Radiation Safety Program.

12. Making courses available for training persons in the safe use of radionuclides and radiation-producing devices.

13. Supervising calibration and maintenance of instruments used in the Radiation Safety Program.

14. Supervising decontamination and preventing the spread of contamination in case of accidents.

15. Notifying NRC and other agencies as required.

C. Deputy Radiation Safety Officer(s) (DRSO)

Routine operation of the Radiation Safety Program under the supervision of the RSO.

D. Principal Investigators (Approved Users)

1. Compliance with the rules given in the AWBREC Radiation Safety Manual and compliance with NRC regulations.

2. Ensure that personnel under their supervision have received sufficient training, as determined by the RSO, to use radioactive materials safely.

3. Maintenence of all required records of receipt, use, storage, survey and disposal of all forms of ionizing radiation.

4. Adequate planning of an experiment or procedure to assure that safety precautions are taken.

5. Communication of pertinent information to the RSO (with respect to) on changes in operational procedures, new techniques, alterations in the physical plant, or new operations which might lead to increased personnel

exposure or contamination levels in the laboratory or the environment.

6. Direction of personnel under their supervision to comply with all recommendations to wear personnel monitoring devices. Conduct routine surveys in laboratory areas, survey of hands and clothing, and submit to biological testing as required.

7. Limit the use of sources to those personnel over whom he has supervision.

8. Ensure that all spills and accidents are reported immediately to the RSO.

E. Individual Users and Technicians

Each person who has any contact with any sources of ionizing radiation has the responsibility to:

1. Keep his exposure to radiation at the lowest practicable level and specifically below the maximum permissible limit listed in the Radiation Safety Manual or its appendices.

2. Wear the recommended radiation detectors such as film badges, ionization chambers, and/or thermoluminescent dosimeters (TLD) for personnel.

3. Survey hands, shoes, body, and clothing as needed for radioactivity. Carry out decontamination procedures as needed. Consult the RSO if necessary.

4. Use all appropriate protective measures which may include protective clothing, respiratory protection, ventilated and shielded glove boxes and hoods.

5. Do not eat, drink, smoke, or store food or beverages in areas where radionuclides are used or stored.

6. Do not pipette radioactive materials by mouth.

7. Check work areas daily or after each radionuclide procedure for contamination.

8. Maintain good housekeeping practices in the laboratory.

9. Maintain good personal hygiene.

10. Label radiation equipment and segregate radiation waste and equipment to avoid cross contamination.

11. Report details of any spill or other accident involving radioactivity immediately to the RSO.

12. Conduct decontamination procedures as supervised by the RSO.

II. REQUIREMENTS FOR THE USE OF RADIONUCLIDES

A. General Regulations

No person shall use within, bring into, or remove from the AWBERC any radioactive material or radiation equipment without authorization from the RSC. The authorization shall be specified in the permit issued by the RSC. Exceptions may be made for the short-term use of very low levels of radioactive materials, but only after consultation with and approval by the RSO.

B. Personnel

1. Principal Investigator

The Research Investigator shall submit an Application for Users of Radionuclides (see Appendix H) which requests information regarding the proposed research, the facility where the work is to be done, the researchers' experience in the safe handling of radiation, etc. The investigator shall acknowledge receipt of a Radiation Safety Manual and shall demonstrate knowledge of radiation handling procedures and safety precautions by signing a form certifying that he has read the Manual (see Appendix J). The investigator shall assure adequate training of his personnel through the completion of the radiation safety course arranged by the RSO or equivalent, and also is responsible for all records required by the RSO. The training must be completed before an individual may use radioactivity.

2. All personnel involved in the project shall read and be responsible for an understanding of the contents of the Radiation Safety Manual. They are jointly responsible with the principal investigator for their training in radiation safety and radionuclide handling procedures and for any violation of radiation safety rules in the laboratory.

C. Laboratories for Radionuclide Work

1. Floors - smooth and continuous surfaces are preferred.

2. Walls, ceilings, and woodwork - surfaces should be nonporous and washable.

3. Ventilation - laboratories with more than 10 microcuries of radionuclides should have hoods with face velocities of at least 100 lineal feet per minute. Documentation of adequate air flow shall be provided by the investigator annually.

4. Equipment - suitable survey and personnel monitoring equipment for the activity, type and level, shall be available.

5. Benches - surfaces are required to be smooth and nonporous with no sharp corners. Absorbent paper should be used.

6. Monitoring - appropriate to the radionuclide(s) used shall be carried out as required by the RSO and/or principal investigator.

III. PROCUREMENT OF RADIONUCLIDES

Procedures for the procurement of radionuclides is as follows:

A. Obtain an Application for Users of Radionuclides, Form EPA-295 (Appendix H), from the RSO or the PSO Officer. Complete the form, filling out parts A and B as appropriate. (A discussion with the RSO or his Deputy at this time is often helpful.)

B. Return the Application to the PSO or the RSO for review by the RSC. If approved, it will be stamped with the "Radionuclide Approved," given a number, and a photocopy returned to the approved user for filing. If not approved, the RSO or his deputy will contact the applicant with with suggestions for a revised protocol if appropriate.

C. When the Application has been approved, the investigator's name is placed on the approved purchaser list for radionuclides. When the investigator receives the photocopy of his approved Application, he may purchase the appropriate radionuclide by:

1. Filling out a standard purchase order requisition. The mailing address for the radioactive materials should be to the Radiation Safety Office. The name of the principal investigator shall be on the requisition.

2. Forwarding the requisition to the Program Safety Officer RSO for the approval signature. The Program Safety Officer will review the purchase request and approve/disapprove before sending to the RSO. (The Purchasing Department will not honor a request for radioactive material without the approval signature on the form.) The RSO receives the material for radiation monitoring to insure its safety before to use by the investigator.

D. The investigator or his department is then notified and he or his assistant may sign for the material at the Radiation Safety Office.

E. When signing for the radionuclide, the person obtaining it will also receive an Isotope Use Record (Appendix E) to maintain as the material is used. When the last of the the material is used or disposed, this record is then returned to the RSO.

F. Procurement of instruments that have sealed sources (chromatographs, etc. shall be approved by the RSO who shall be kept aware of the status of that instrument).

IV. STORAGE OF RADIONUCLIDES

A. Liquids and Solids

All stored radioactive material shall be clearly labeled at all times giving radionuclide(s) chemical form, the activity (disintegration rate), the date of activity, and the name of the responsible investigator.

Storage sites for large amounts of radioactive materials should be as remote from occupied areas as practicable, or surrounded by adequate shielding. Background radiation in unrestricted areas should be such that individuals continuously in these areas will not receive a dose in excess of 2 millirems (20 microsieverts) in any one hour, or 100 millirems (1 millisievert) in any seven consecutive days. Whole body exposure in unrestricted areas shall be such that any individual will not receive a dose in excess of 0.5 rems (500 mrem or 5 millisieverts) in any one calendar year. These dose levels also apply to persons in adjoining rooms as well as those on floors above and below. The storage place should be chosen so as to minimize risk from fire, and should be provided with a suitable means of exit. Storage areas shall be well marked with "Caution - Radioactive Materials" and "Caution - Radiation Area" signs where applicable. The name and phone number of the responsible person, the RSO and the DRSO shall be posted in a conspicuous place near the area.

B. Gases

The storage requirements listed in Section IV. A. apply as well as the following: radioactive solutions that emit gases shall be labeled and kept in approved hoods which are provided with filters and have adequate ventilation (100 lineal feet per minute.) Quantities of materials shall be kept to a minimum. For maximum permissible concentration in air, consult RSO.

V. RADIATION PROTECTION MEASURES

A. External Exposure

The basic protective measures to reduce radiation exposure are time, distance, and shielding. In every situation these three factors must be considered jointly. Although, shielding is desirable in reducing exposure, do not overlook that doing the job in less time can be just as effective as increasing the shielding. Working twice as far from a point source is as effective as doing the job in one-fourth the time. Continuous use of monitoring equipment is the best method of evaluating the hazard and reducing the radiation exposure. Every use of radionuclides may constitute an external hazard, and an appropriate monitor shall be available during these operations.

B. Internal Contamination

The prevention of internal exposure is more exacting and less easily achieved than is protection from external exposure. The maximum permissible levels of radioactive contamination in the air or on laboratory surfaces are often of such a low level that they cannot be detected with ordinary survey instruments. If low level contamination is suspected (anytime there is a spill), contact the RSO for a survey of surface and/or air contamination. The general policy for working with radionuclides is to use such equipment and procedures which will most reduce the probability of ingestion or inhalation of radionuclides into the body. Outlined below are general rules and procedures for this purpose:

1. Eating, drinking, smoking, or other tobacco use, use of cosmetics, and the storage of edibles are not permitted in laboratories or rooms where radioactive materials are used or stored.

2. Solutions shall not be pipetted by mouth.

3. Protective clothing appropriate to working conditions shall be worn. A laboratory coat and gloves are the minimum protective clothing to be worn. Monitor clothing before leaving an area where radioactive materials are handled. CONTAMINATED CLOTHING SHALL NOT BE WORN OUTSIDE THE LABORATORY, i.e., in offices, counting rooms, etc. NEVER WEAR LABORATORY COATS to the cafeteria or public areas such as the auditorium, library, conference rooms, etc.

4. Wash hands thoroughly before leaving the laboratory.

5. If contamination is suspected, all work shall be halted immediately and the RSO contacted to evaluate the condition and give advice.

6. All injuries shall be monitored to determine possible contamination if contamination exists, call the RSO at once.

7. Special protection is required for wounds so as to prevent the entry of radioactive materials. Waterproof adhesive tape should seal any [other] bandaging.

8. Everything in the room shall be considered contaminated and should be monitored before removing from the room.

9. All persons issued monitoring equipment (film badges, etc.) shall wear the issued equipment at all times when in or near the radiation areas. They shall not wear them home. The badges shall be stored in a radiation-free area.

10. All persons working with radioactive materials shall be aware of radiation safety procedures. The principal investigator is responsible for seeing that his workers have been properly trained and have read, understand, and are familiar with this "Radiation Safety Manual."

11. Radioactive material shall be used and stored in a way which prevents unauthorized access.

12. All containers for radioactive material shall be properly labeled (per 10 CFR, part 20 and Section IV. A of this manual).

13. Individuals involved in operations which utilize at any one time more than 100 mCi of tritium in a noncontained form, (other than metallic foil) shall have

bioassays performed within 1 week following a single operation, and at weekly intervals for continueous operations. Tritium shall not be used in such a manner as to cause any individual to receive a radiation exposure such that urinary excretion rates exceed 28 uCi of tritium per liter, when averaged over a calendar quarter.

C. Handling Procedures

1. Radioactive materials are to be handled only by persons whose training has been approved by the RSO and who are aware of the hazards of the material.
2. The shipping container shall be opened and treated as though it were contaminated inside until monitoring to prove differently.

3. When handling radioactive material (except in the shipping container) personnel shall wear protective gloves, use shielding when necessary, and work on a surface covered with absorbent paper or equivalent material.

4. Remote handling equipment should be used when the external radiation of a container exceeds 3mR/hr at 1 centimeter (maximum permissible exposure rate to hands and forearms for a 40-hour week).

5. To reduce the risk of spills to a minimum

a. Use double containers

b. Use protective covering and lids

c. Use unbreakable containers to store radionuclides

d. Use caution in transfers; try a "dry run" without using radioactive materials

e. Use glove box for dusty materials

f. Use mechanical pipettors; never pipette by mouth

g. Use absorbent paper or equivalent to cover work surface to contain any possible spill

D. Good Housekeeping Habits

Much of the job of preventing the spread of contamination is a matter of good housekeeping.

1. Keep the laboratory neat and clean. Keep the work area free of equipment and materials not required for the immediate procedure.

2. Wear rubber or plastic gloves when handling radioactive material.

3. Wash hands and arms thoroughly before handling any object which goes to the mouth, nose, or eyes. Monitor the hands whenever contamination is suspected and decontaminate immediately.

4. Keep fingernails short and clean. Do not work with radioactive materials if there is a break in the skin below the wrist unless the wound is so protected that radioactive materials cannot gain access to the body. Cover the break with tape (waterproof) and wear rubber gloves.

E. Restriction and Labeling of Radiation Areas

All radiation areas shall be properly labeled and restricted to authorized personnel only. The design of the radiation symbol is given in Title 10, Section 20.203, of the Code of Federal Regulations. A sign bearing the radiation caution symbol and the words "Caution High Radiation Area" shall be posted in such an area where a major portion of the body could receive in any 1 hour a dose in excess of 100 millirems (1 millisievert). A sign bearing the radiation caution symbol and the words "Caution Radiation Area" shall be posted when the level in such an area is such that a major portion of the body could receive in any 1 hour a dose in excess of 5 millirems (50 microsieverts). A sign bearing the radiation caution symbol and the words "Caution Airborne Radioactivity Area" shall be posted when any any room, enclosure, or operating area in which airborne radioactive materials exist in concentrations in radiotion excess of the amounts specified in Appendix B of 10 CFR 20, Table 1, Column 1. A sign bearing the radiation caution symbol and the words "Caution Radioactive Materials" shall be displayed on each container in which is transported, stored, or used a quantity of any licensed material greater than the quantity of such material specified in Appendix C of 10 CFR 20.

Form NRC-3 "Notice to Employees" (see Appendix D) shall be posted in a sufficient number of places in every establishment where employees are engaged in activities licensed by the NRC to permit them to observe this Notice on the way to and from their place of work.

F. Monitoring and Survey

Each person is responsible for monitoring his personal clothing, shoes, and laboratory equipment. Each laboratory and/or special project is responsible for providing appropriate survey devices and having them calibrated annually.

1. Personnel Monitoring

a. Film Badges

Any person who is likely to receive 25 percent of the maximum permissible dose (i.e., 25 millirems [250 microsieverts] per week averaged over 13 consecutive weeks) shall be issued a film badge.

b. Pocket Dosimeters (chambers)

Personnel working with any source of radiation where a daily exposure of more than 20 millirems (200 microsieverts) is probable should wear a pocket chamber. As a rule of thumb, if the radiation level exceeds 100 mR/hr at any point (High Radiation Area), pocket chambers are called for.

c. Survey Meters

Every radionuclide laboratory shall have a working survey meter available, usually of the Geiger-Mueller type. Personnel in the laboratories shall use this instrument to check for contamination and for such routine use as:

1. Checking laboratory surfaces, glassware, and tools for beta-gamma contamination.

2. Checking hands, shoes, and clothing.

3. Measuring the radiation level from low level sources (less than 20 millirems per hour).

d. It is difficult to survey laboratory areas where low-energy beta emitters (such as 14C, 3H, etc.) are used. Filter paper or cotton swab wipes must be taken in these areas and the wipes counted in a proper instrument (such as liquid scintillation counters).

2. Laboratory Monitoring and Survey

Surveys - Wipe tests shall be taken and recorded as agreed in the Application for Use of Radionuclides Form (see Appendix H) between inspections by the RSO. Frequency of the wipe tests depends upon amounts of radionuclide used, relative hazard of the radionuclide, the type of experiment conducted and whenever contamination or a spill is suspected. The user shall perform a survey via wipe test of laboratories where licensed material is used in unsealed forms at least monthly during periods of use. Periodic inspection of the radionuclide laboratories shall be conducted by the RSO. The RSO shall have a floor plan of each laboratory. During the periodic checkup, the RSO may record on this floor plan dose rates at various points such as sinks, lab tables, hoods, and handling equipment using the appropriate survey meter. Also recorded on this floor plan will be the wipe tests of the most frequently used areas. Wipes will be made with a piece of moistened filter paper or swab and depending on the type of source present, counted for contamination.

Sampling of air may be performed by the RSO in various areas in which radionuclides are being used as needed. Tritium concentration in the air will be monitored near tritium-labeling experimental setups if it is possible for concentration to exceed limits in Table 1, Column 1, Appendix B, 10 CFR 20.

All potentially exposed personnel involved in tritium-labeling procedures will be subjected to a regular program for urinary monitoring as follows:

Total Quantity of Tritium Used	Frequency of Use	Frequency of Bioassy
10 mCi - 100 mCi	within 6 months	within 6 months
100 mCi - 8 Ci	weekly - 3 months	weekly - 3 months
8 Ci or higher	daily - weekly	daily - weekly

When radiochemical procedures using iodine-125 or -131 are performed, thyroid counting of personnel involved (others from the laboratory may also be counted as controls) shall be performed within 3 days after iodination if 2 millicuries or more of iodine are used.

3. Animal Room Monitoring

If gamma-emitting radionuclides are administered to

animals, the room in which the animals are housed should be labeled with a "Caution Radiation Area" sign. Periodic monitoring of the animals will be made by the personnel working in the laboratory at intervals specified by the RSO. Exposure rates should be measured and recorded at a distance of 1 foot from the animals, at the initiation of each new experiment. If the exposure rate at 1 foot is greater than 2.25 millirems per hour, contact the RSO.

G. Calibration of Survey Meters

All survey meters and pocket dosimeters used routinely in the Radiation Safety Program shall be calibrated at least once every year. Upon completion of the calibration, an instrument calibration record will be posted on the survey meter indicating the date of calibration. The user will be responsible for maintaining the calibration at intervals not exceeding 1 year.

H. Permissible Exposures

The maximum permissible dose for a radiation worker is 5 rems per year (50 millisieverts per year) or 100 millirems per week (1 millisievert per week).

The maximum permissible average body burden of radionuclides for persons outside of the controlled area and attributable to the operations within the controlled area shall not exceed one-tenth of that for a radiation worker, 0.5 rem per year (i.e., 5 millisieverts) or 10 millirems per week (100 microsieverts).

Persons under 18 years of age shall not be occupationally exposed to ionizing radiation. Their yearly exposure shall not exceed 0.1 rem (1 millisievert) per year from education activities. A special policy has been adopted for students (see Appendix L).

No one without proper training shall be allowed to transport or handle other types of radioactive materials, such as sealed sources, radioactive phantoms and standards. Students over 18 years of age shall not receive doses exceeding 0.5 rem (5 millisieverts) per year in addition to natural background and medical exposures (see NCRP Reports 32 and 39), unless they are also occupational workers.

The AWBERC is committed to the ALARA PRINCIPLE, i.e., to keeping individual and collective exposure AS LOW AS REASONABLY ACHIEVABLE.

Female Workers

1. All female workers of childbearing age shall be advised by the supervisor about the potential hazard of radiation to the developing human fetus before beginning work with radionuclides or X-ray producing equipment, whether pregnant or not (see Appendix K).

2. It is the responsibility of any female radiation worker to notify her supervisor whenever she suspects that she is pregnant.

3. The exposure during pregnancy is limited to 0.5 rem (5 millisieverts) on the film badge as a whole body dose.

4. The RSO should be advised as to the expected date of delivery, which shall be treated as a confidential medical communication.

Information concerning possible health risks to children of women who are exposed to radiation during pregnancy is found in Appendix K.

I. Contaminated Equipment

1. Definition:

Radioactive contamination is defined as the deposition of radioactive material in any place where it is not desired and particularly in any place where presence may be harmful. Contaminated equipment shall not be used again until properly decontaminated (see Section VIII).

2. Decontamination Procedures:

Equipment that may be reused should be decontaminated. See Section VIII Decontamination Procedures. Contaminated equipment no longer of any use may be discarded in a disposal drum. Request assistance from the RSO.

J. Instructions for Visitors

All protection measures pertinent to personnel safety mentioned above section shall apply to all visitors. No visitors shall be permitted in any laboratory using a radiation source unless accompanied by a qualified individual familiar with the hazards involved. All visitors shall shall be issued a personnel monitoring device when they enter an area in which radioactive materials are located in such amounts that they constitute a potential personnel hazard or increase the possibility for spread of contamination. Accumu-

lated doses shall be recorded for the visitor along with the individual's name, social security number, age, address, and this information sent in a written memorandum to the RSO to be kept on file.

VI. DISPOSAL

Records of the amounts in microcuries of all radionuclide disposals must be maintained (see Appendix E). Disposal procedures for drums are subject to change and current requirements may be obtained from the RSO. Radionuclides at the AWBERC are disposed of in the following manner:

A. Decay

If the radionuclide is short lived, it may be stored until the activity has decayed to approximate background levels. (Usually less than 0.1 millirem per hour with no shielding.) If the half-life is greater than 30 days, this method becomes impractical.

B. Liquid Disposal

1. Sewer Disposal

If the radionuclide is readily soluble or dispersible in water, it may be flushed down the drain provided the concentration is below the maximum permissible levels. An assay shall be made to determine the exact amounts of activity present and the dilution necessary. See Appendix C for the maximum permissible discharge of some radioactive materials into an authorized disposal sink. Only sinks designated as disposal sinks shall be used for radionuclide disposal.

2. Nonsewer Disposal

If a liquid waste cannot be disposed of by the sewer method, it may be disposed of by a commercial disposer in compliance with NRC regulations. Check with the RSO for current acceptable procedures for drum disposal of radioactive waste. No liquids shall be poured directly into a disposal drum. It may also be precipitated or evaporated and treated as a solid waste. Care should be taken in handling dry material (i.e., dust) to prevent air contamination. Or, the waste liquid can be stored in a properly identified liquid waste container to be disposed of by the RSO. A drum not properly packed cannot be accepted for shipment and disposal.

A Radioactive Waste Container Log Form, (Appendix I) shall be kept for all radioactive disposal drums. If the drum contains liquids, there shall be enough absorbent material in the drum to absorb TWICE the amount of liquid present.

C. Incineration

Combustible material containing radionuclides may be incinerated in the Animal Wing Incinerator only if the concentrations in effluent to unrestricted areas are not in excess of the limits specified in Appendix B of 10 CFR 20, Table II. (See Appendix F of this manual.)

All animals, excreta, and other material containing radionuclides that are to be incinerated shall be contained in a plastic bag and shall be clearly labeled with laboratory location, personnel in charge, the radionuclide contained therein, the amount in microcuries of the radionuclide, and the date when this amount was present. The permissible concentrations in effluents to unrestricted areas for the incinerator in microcuries per hour burning time are given in Appendix F. A record of the amounts, in microcuries, of all radionuclides incinerated must be maintained. The Incineration Record Form (Form EPA-300) is shown in Appendix G. This record is kept by personnel operating the incinerator.

D. Solid Wastes

All dry solid wastes should be stored in steel waste cans or drums to be shipped to a disposal agency. The laboratories which produce solid waste should have provisions for temporary storage. Check with the RSO for current acceptable procedures for drum disposal of radioactive waste.

VII. EMERGENCY PROCEDURES

Emergencies resulting from accidents in laboratories working with radioactive materials will range from simple spills of small amounts of radioactive materials, where no serious contamination problem results, to major disasters occurring from many causes. Correspondingly, the hazards resulting from such accidents will cover the range of situations from no hazard to very serious situations involving extreme radiation hazards and possible bodily injury. In view of the complicating factors that may arise during such emergencies, simple rules of procedure cannot be set down covering all situations of radiation danger. However, in any emergency, primary concern must always be the protection of laboratory personnel from radiation hazards. Second should be the confinement of the contamination to the local area of the accident to the greatest degree possible.

A. Whom to Call and When

In the event of an emergency or a suspected emergency, e.g., spills, bodily injury, fire, etc., the RSO or other person on the Radiation Safety Committee shall be notified immediately. (see Appendix A). In addition, each laboratory shall post the location of the nearest fire alarm and phone number of the fire department and a copy of Appendix A.

B. Lost Sources

In the event any significant quantity of radioactive material is lost, notify all personnel in the lab area or building if necessary. Evacuate the area if necessary. Contact the RSO at once and request consultation and survey.

C. Minor Spills Involving No Radiation Hazard to Personnel

1. Notify all other persons in the room at once and confine them nearby until monitoring can be completed.

2. Control/contain air movement and seal area.

3. Notify the RSO immediately.

4. Permit only the minimum number of persons necessary to deal with the spill in the area.

5. Confine the spill immediately.

   a. Liquid Spills: Don protective gloves, lab coat (or the equivalent), and shoe covers if necessary. Collect spill on absorbent paper.

   b. Dry Spills: Don protective gloves, lab coat (or the equivalent), and shoe covers. Dampen dry radioactive material with water, taking care not to spread the contamination or create an airborne hazard. Then the material can be either scooped up or, if soluble in water, collected on absorbent material.

6. Decontaminate (see Section VII. B).

7. Monitor all persons involved in the spill and cleaning.

8. Permit no persons to resume work in the area until a survey is made and approval of the RSO is obtained.

9. Prepare a complete history of the accident and subsequent activity related thereto for the RSO and the RSC.

D. Major Spills Involving Radiation Hazard to Personnel

1. Notify all persons to vacate the room at once.

2. Confine the spill to as small an area as practicable.

3. If the spill is on the skin, flush thoroughly. Contain washings, if possible, for evaluation of contamination levels.

4. If the spill is on the clothing, discard outer or protective clothing at once and place in a plastic bag.

5. If possible, switch off all fans and air conditioners if the ventilation system could spread the contamination to other areas. If the ventilation system leads directly to the outdoors, it may be more advantageous to leave the system on to reduce airborne levels within the room. Where high levels of activity are to be handled, these controls or auxiliary controls should be outside of the work room.

6. Vacate the room.

7. Notify the RSO immediately.

8. Take immediate steps to decontaminate personnel involved as necessary.

9. Decontaminate area under supervision of RSO (personnel involved in decontamination must be adequately protected).

10. Monitor all persons involved in the spill and cleaning to determine adequacy of decontamination.

11. Permit no persons to resume work in the area until a survey is made and approval of the RSO is obtained.

12. Prepare a complete history of the accident and subsequent activity related thereto for the RSO and the RSC.

E. Accidents Involving Radioactive Dusts, Mists, Fumes, Organic Vapors and Gases

1. Hold breath, switch off air circulating devices, etc., if time permits and controls are in the room.

2. Vacate the room.

3. Notify the RSO immediately.

4. Close and seal all doors. Post conspicuous warning signs.

5. Report to the RSO all known or suspected inhalations of radioactive materials at once. Monitor all persons suspected of contamination.

6. Determine the cause of contamination.

7. Evaluate the hazard and the necessary safety devices for safe re-entry.

8. Decontaminate the area under supervision of the RSO.

9. Perform air survey of the area before permitting work to resume.

10. Prepare a complete history of the accident and subsequent activity related thereto for the RSO and the RSC.

F. Injuries to Personnel Involving Radiation Hazard

1. Wash minor wounds immediately, under running water, while spreading the edges of the wound.

2. Report all radiation accidents to personnel (wounds, over-exposure, ingestion, inhalation) to the RSO immediately.

3. The University of Cincinnati Hospital Emergency Medicine Department should be contacted.

4. No person involved in a radiation injury shall return to work without the approval of the RSO and the attending physician.

5. Prepare a complete history of the accident and subsequent activity related thereto for the RSO and the RSC.

G. Fires and Other Major Emergencies

1. Notify all persons in the room and building at once.

2. Attempt to put out fire if radiation hazard is not immediately present and if there is no threat to personnel in fighting the fire.

3. Avoid inhalation of fumes. Breathe through wet cloth if necessary.

4. Notify the RSO.

5. Notify the Fire Department, Security, and Maintenance.

6. Activities of fire-fighting and other emergency personnel should be governed by the restrictions of the RSO.

7. Following the emergency, monitor the area and determine the protective devices necessary for safe decontamination after consultation with the RSO.

8. Decontaminate under the supervision of RSO.

9. Permit no person to resume work without the approval of the RSO.

10. Monitor all persons involved in combating the emergency.

11. Prepare a complete history of the emergency and subsequent activity related thereto for the RSO and the RSC.

VIII. DECONTAMINATION PROCEDURES

A. General Considerations

1. Prevent Spread of Contamination

The RSO or Deputy should be called for assistance as soon as possible whenever a spill occurs. The first considerations after personnel safety are confinement of radioactivity and decontamination. Many factors must be considered, including tracking by persons, movement by air currents (hoods, fans, etc.), water, dusting, mopping, and other physical actions. To minimize spreading, decontaminate the spill from the outside toward the center.

2. Radiation Protection Guide Levels of Contamination

The maximum limits of contamination generally allowed are:

Skin and Hands:	alpha - 150 dpm/100 cm2 beta and gamma - 0.3 millirems per hour /100 cm2
Clothing:	The maximum limits are the same as those for skin and hands.
Glassware:	The maximum limits for glassware that is handled with bare hands are the same as those for skin and hands.
Laboratory Tools:	The maximum limits for laboratory tools that are handled with the bare hands are the same as those for skin and hands.

There may be some instances when these levels cannot be attained using routine decontamination procedures. In these cases, the RSO should be consulted.

3. Develop a Plan

Successful decontamination calls for planned action. Although speed is desirable, a spur-of-the-moment action at decontamination can cause more harm than good. After a spill has been confined, make a thorough plan of the steps to be taken in the decontamination procedure.

4. Monitoring

Make full use of instruments and available assistance. Each step of decontamination should be monitored. One person should be kept clean (not contaminated) to operate the instruments and aid in monitoring. When the instruments become contaminated, it is not possible to obtain additional accurate information. Protective clothing, footwear, gloves, and respiratory masks should be used as needed.

5. Records

Complete records should be made of all activities. Tape recorders and instant cameras are useful in assembling the necessary information. Reports should be filed with the RSO. In most cases, the RSO will be involved so that a joint report can be filed.

6. Provisions must be made for the proper disposal of contaminated cleaning solutions and other contaminated articles. In some instances, it may be judged better to dispose of a contaminated article as radioactive waste rather than to attempt to decontaminate it.

B. Specific Procedures

Where possible, the preferred decontamination agent is listed first. (see next page).

CONTAMINATED AREA	DECONTAMINATING AGENT	REMARKS
Skin and Hands	Mild soap and water.	Wash 2-3 min. and monitor So not wash over 3-4 min.
	If necessary, follow by soft brush, heavy lather, and tepid water.	Use light pressure with heavy lather. Wash for 2 min, 3 times. Rinse and monitor. Use care not to scratch or erode skin. Apply lanolin or hand cream to prevent chapping.
	Other Procedures	
	Commercial products such as Radiac Wash or Isoclean.	Follow instructions on container. Use care not to scratch or erode the skin.
		Consult with Radiation Safety Office for other recommendation
Wounds (cuts and breaks in the skin)	Running tap water, report to Medical Officer and Radiation Safety Officer as soon as possible.	Wash the wound with large volums of running water immediately (within 15 sec). Spread the of the wound to permit flushing action by the water.
Inhalation and Ingestion	Consult Radiation Safety Office immediately.	

CONTAMINATED AREA	DECONTAMINATING AGENT	REMARKS
Clothing	Wash - if levels permit	Use standard laundering procedures. 3% EDTA or citric acid may be added to was water. Wash water must be below MPL for sewer dsiposal.
See rubber and leather under specific materials	Store	To allow for decay if contamination is short-lived.
	Disposal	Treat as solid radio-activer waste if necessary.
Glassware	Soap or detergent and water	Monitor wash water and plan disposal of it.
	Isoclean	Soak 24-48 hours.
	Chromic acid cleaning solution	Monitor wash water and plan disposal of it.
	Suggested Agents	Elements Removed
	Oxalic Acid, 5% (caution-poson).	Zr, Nb, Hf.
	Versene (EDTA) 5% Sol. ETDA 3% Sol. NH_4H To make, dissolve in order: 1) Versene (EDTA), 5% 2) Conc. NH_4OH., 3% by volume 3) Glacial acetic acid, 5% by volume.	Alkaline Earth Metals: Be, Mg, Ca, Sr, Ba, Ra, P as PO_4.

CONTAMINATED AREA	DECONTAMINATING AGENT	REMARKS
Glassware (continued)	HCL, 10% by volume	Alkali metals, Na, K, Rb. Cs, and strongly absorbed metals like Po. Trivalent metals, Al, Sc, Y, La, Ce, Pr, Nd, Pm, Sa, Eu. Rare Earths, Ac, Ga, In, Ti, B. Transition metals, Cu, Zn, Fe, Co, Ni, Cd, Sn, Hg, Pd, Th, U, Ag. (Always consider the radioactivity of the cleaning solution when disposing of it.)
Laboratory Tools	Detergents and water, stem cleaning.	Use mechanical scrubbing
	Isoclean, Radiacwash	Soak
Metal Tools	Dilute nitric acid, 10% solution of sodium citrate or ammonium bifluoride	As a last resort, use HCl HCl on stain less steel.
	Isoclean, Radiacwasd	Soak
	Metal polish, other abrasives	Such as brass polish Use caution as these procedures may spread contamination.

CONTAMINATED AREA	DECONTAMINATING AGENT	REMARKS
Walls, Floors, Benches	Detergents and water with mechanical action.	This should be the first of decontamination tried.
	Isoclean, Radiacwash	Use mechanical scrubbing action.
	Vacuum Cleaning.	The exhaust of the cleaner must be filtered to prevent escape of contamination.
Specific Materials		
Rubber	Washing or dilute HNO_3	(Short-lived contami- be covered up to await decay.)
Glass, Plastic	See the above section on glasswaare	
Leather	Very dificult to decontaminate.	
Linoleum	Kerosene, ammounium citrate, dilute mineral acids	Remove and discard as waste.
Ceramic Tile	Mineral acids, ammonium citrate, trisodium phosphate.	Consider removal and as radiation waste. *Scrub hot 10% solution into surface and flush thoroughly with hot water.
Paint	Paint remover.	*Usually best to remove the paint and repaint
Brick anc Concrete	20% HCl acid solution	*If this is not successful, concrete must be removed or suitably covere.
Traps and Drains	1) Flush with water 2) Scour with rust remover 3) Soak in a solution of citric acid 4) Flush again	*Follow all 4 steps *Consult with the RSO

XI. GENERAL REFERENCES

Radiation Protection in Educational Institutions (1966), NCRP Report No. 32.

Radiation Protection in Veterinary Medicine (1970), NCRP Report No. 36.

Basic Radiation Protection Criteria (1971), NCRP Report No. 39.

Protection Against Radiation from Brachytherapy Sources (1972), NCRP Report No. 40.

Tritium Measurement Techniques (1976), NCRP Report No. 47.

Radiation Protection for Medical and Allied Health Personnel (1976), NCRP Report No. 48.

Report of Committee III on Protection Against X-rays up to Energies of 3 MeV and Beta- and Gamma-Rays from Sealed Sources (1960), ICRP Publication 3.

Report of Committee V on the Handling and Disposal of Radioactiv Materials in Hospitals and Medical Research Establishments (1964), ICRP Publication 5

Principles of Environmental Monitoring related to the Handling of Radioactive Materials, (1955) ICRP Publication 7.

Recommendations of the International Commission on Radiological Protection (Adopted September 17, 1965), ICRP Publication 9.

Report of Committee IV on Evaluation of Radiation Doser to Body Tissues from Internal Contamination Due to Occupational Exposure, ICRP Publication 10.

The Assessment of Internal Contamination Resulting from Recurrent or Prolonged Uptakes (1971), ICRP Publication 10A.

General Principles of Monitoring for Radiation Protection of Workers, (1968) ICRP Publication 12.

Radiation Protection in Schools for Pupils up to the Age of 18 Years, (1970), ICRP Publication 13.

Protection Against Ionizing Radiation from External Sources, (1969), ICRP Publication 15.

Title 10, Chapter 1, CFR, U. S. Nuclear Regulatory Commission, Rules and Regulations, Part 19, Notices, Instructions, and Reports to Workers; Inspections. Part 20, Standards for Protection against Radiation.

Review of the Current State of Radiation Protection Philosophy, NCRP Report No. 43

Review of NCRP Radiation Dose Limits for Embryo and Fetus in Occupationally Exposed Women, NCRP Report No. 53.

Medical Radiation Exposure of Pregnant and Potentially Pregnant Women, NCRP Report No. 54

Radiation Protection - A Guide for Scientists and Physicians by Jacob Shapiro, 1972.

Radiological Health Handbook - U.S. Department of Health, Education and Welfare, 1957.

Recommendations of the ICRP, (1977) ICRP Publications 26.

Conditions and Limitations on the General License Provisions of 10 CFR 150.20, NUREG-0426.

IX. RADIATION-PRODUCING APPARATUS

All apparatus producing ionizing radiation (such as electron microscopes, X-ray machines, etc.) is under the control of the RSO and shall be registered with the office. Periodic surveys of all radiation-producing equipment and areas in (which these machines) are located will be conducted by the RSO.

GENERAL CONSIDERATIONS

A. Radiation-producing apparatus shall be operated only by a qualified individual or by personnel under the direct supervision of a qualified individual

B. The person using radiation-producing apparatus shall be classified as a radiation worker (occupationally exposed individual) and shall wear a personnel monitor.

C. Before radiation-producing apparatus is put into regular use, a complete radiation survey shall be carried out to insure that the walls and barriers offer sufficient protection and that the equipment complies with applicable safety regulations. The radiation checks must include all positions of regular as well as partial occupancy. This survey shall also include the evaluation of radiation levels on the floors above and below and of areas in adjacent structures. If at any time there are structural changes or relocations of equipment, a new survey shall be performed.

D. "Caution - Radiation Area" warning signs shall be posted in all areas where a person, could receive an exposure in excess of 5 mrem (50 microsieverts) in any 1 hour or 100 millirems (1 millisievert) in 5 consecutive days. Appropriate "High Radiation Area" warning signs shall be posted at the entrance of any area wherein a person could receive an exposure of 100mrem (1 millisievert) or more in any 1 hour. In certain instances, other precautions such as locking the entrance to the room and the use of interlocks may be advised. These additional devices shall be checked periodically.

E. All restrictions or recommendations made by the RSO on useing of the radiation-producing apparatus shall be followed.

F. All regulations included in the "Ohio Radiation Protection Standards" (as issued by the Ohio Department of Health) shall apply. National Council on Radiation Protection and Measurements (NCRP) Reports No. 48 (Radiation Protection for Medical and Allied Health Personnel) and No. 49 (Structural

Shielding Design and Evaluation for Medical Use of X-ray and Gamma Rays of Energies Up to 10 MeV) may be used as guidelines.

X. SEALED SOURCES

All sealed sources are under the control of the RSO.

A. The RSC shall approve purchases of sealed sources and shall be notified of all sealed sources brought into the AWBERC. Information shall cover the following:

1. Chemical and physical form of the radioactive source and its source container.

2. Permanent location

3. Method of accountability

4. Method of use

5. Places of use

B. Each beta or gamma emitting sealed source, containing 100 microcuries or more of byproduct material (except tritium) with a half-life greater than 30 days shall be tested for leakage and/or contamination every 6 months. The test shall be performed on the sealed source surface or on the accessible surfaces of the device in which such a source is permanently or semi-permanently mounted. The tests shall be performed using moistened cotton applicators or filter paper. Wipes shall be counted with appropriate scintillation instrumentation, (i.e., crystal scintillation, liquid scintillation or gas-flow) to determine radioactivity. Records of leak test results shall be maintained by the RSO. These tests shall be performed every six months (every 3 months for alpha emitters, 10 millicuries or larger) and shall be supervised by the RSO. Servicing, maintenance and repair of source shall be performed by commercial source supplier. supplier.

C. Periodic surveys of all areas where radium is stored shall be made by the RSO. Wipe tests shall be made of all radium storage containers every 6 months by the Radiation Safety Office. Unlike the other alpha-emitting sources possessed by the EPA, radium is regulated by the State of Ohio. Leakage testing requirements for radium differ from those required by the NRC. Wipe tests of the individual radium sources shall be made when container wipes indicate higher than normally observed values. Records shall be kept by the RSO.

APPENDIX A

RADIATION SAFETY OFFICER AND DEPUTY

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Radiation Safety Officer
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Cincinnati, Ohio 45238

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Coml. 569-7269
Home: 922-4129

Louis W. Lefke, Chairman
Radiation Safety Committee
5743 Shady Hollow Lane
Cincinnati, Ohio 45230

FTS: 569-7953
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DEPUTY RADIATION SAFETY OFFICERS IN CASE OF ACCIDENT

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APPENDIX B
Units and Definitions

Half-life, radioactive - time for the activity of any particular radionuclide to be reduced to one-half of its initial value.

High radiation area - means any area accessible to personnel in which there exists radiation originating in whole or in parts within licensed material at such levels that a major portion of the body could receive in any 1 hour a dose in excess of 100 millirems.

Ion - an atom that is electrically charged because of gain or loss of electrons.

Ionization - the production of ions in a material, usually by exposure to X-ray or radiations from radioactive materials.

Irradiation - exposure to radiation.

Isotope - one of several nuclides of the same element, having the same nuclear charge but different nuclear mass.

Linear energy transfer (ET) - physical measure for gauging the relative effectiveness of equal absorbed doses from different particles in producing injuries. The higher the LET of the radiation, the greater the injury produced for a given absorbed dose.

Maximum permissible dose (MPD) - the maximum dose equivalent that the body of a person or specific parts thereof shall be permitted to receive in a stated period of time.

Nuclide - a particular nuclear species characterized by a specific atomic number and mass number.

Pocket ionization chamber - a type of personnel monitor activated by radiation producing ions within it.

Qualified individual - has completed and has had approval (by Radiation Committee) EPA-294, "Certification for Use of Radiation."

Quality factor (QF) - the factor expressing the relative effectiveness of a given particle based on its linear energy transfer (LET).

Rad - a unit of absorbed dose. 1 rad is 100 ergs per gram.

Radiation area - means and area accessible to personnel in which there exists radiation, originating in whole or in part within licensed material, at such levels that a major portion of the body could receive in any 1 hour a dose in excess of 5 millirems or in any 5 consecutive days a dose in excess of 100 millirems.

APPENDIX B
Units and Definitions

Absorbed dose - the mean energy imparted to matter by ionizing radiation per unit mass of irradiated material at the place of interest. The unit of absorbed dose is the rad.

Activity (Radioactive) - the number of radioactive disintegrations occurring per unit time in a given quantity of radionuclide. The unit of activity of the curie. See Curie.

Alpha particle - ( ) the nucleus of a helium atom ejected from a radioactive nucleus when it disintegrates.

Attenuation - decrease in exposure rate of radiation caused by passage through material.

Becquerel (Bq) - the SI (International System of Units) unit for radioactivity
= 1 disintegration/second
= 2.7×10^{-11} curie; to replace currently used curie (Ci).

Beta particle - (b) electrons, positive or negative, emitted by the nucleus of a radioactive atom when it disintegrates.

Coulomb/kilogram (c/kg) - expression for SI unit of exposure (no special name given) to replace currently used roentgen (R).

Curie - the quantity of any radioactive material in which the number of disintegrations is 3.7×10^{10} per second.

Doser equivalent - a quantity useeed for radiation protection purposes that expresses on a common scale for all radiations, the irradiation incurred by exposed persons. It is defined as the absorbed dose (rad.) times QF times certain modifying factories. The unit of the dose equivalent is the rem.

Exposure - the exposure of X- or gamma radiation at a certain place, based upon its ability to produce ionization. The unit of exposure is the roentgen (R).

Film badge - a pack of appropriate photographic film and filters used to determine radiation exposure.

Gamma rays - ( ) electromagnetic radiation like X-rays, emitted by the disintegrating radioactive nucleus. In general, gamma rays are more pene-

Gray (Gy) = the SI unit for absorbed dose = 100 rad. = 1 Joule/kilogram; to replace currently used radiation absorbed dose (rad.).

Radiation producing apparatus - apparatus from which electromagnetic radiation may be emitted as a result of acceleration of particles.

Rem - the unit of dose equivalent. For beta, gamma, and X-ray radiation, the number of rems may be considered equal to the number of rads or roentgens.

Restricteed area - any area access to wehich is controlled by the licensee for purposes of protection of individuals from exposure to radiation and radioactive materials. "Restricted area" shall not include any areas used as residential quarters, although a separate room or rooms in a reisdential building may be set apart as a restricted area.

Roentgen - the special unit of exposure for X- or gamma radiation. One produces 2.58×10^4 coulombs per kilogram of air.

Shall - denotes that the ensuing recommendation is necessary or essential to meet the currently accepted standards or protection.

Should - indicates advisory recommendations that are to be applied when practicable in the interest of reducing radiation exposure.

Sievert (Sv) - the SI unit for dose equivalence = 100 rem = 1 Joule/kilogram; to replace currently used unit of dose equivalence (rem).

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

Wipe test - a test for radioactive contamination in which the suspected surface or area is wiped with a filter paper (or other substance) which is then immediately tested for the presence or radioactivity.

APPENDIX B (con't)

TABLE OF SI PREFIXES

Factor	Prefix and Symbol	Factor	Prefix and Symbol
10^{18}	exa, E	10^{-1}	deci., d
10^{15}	peta, P	10^{-2}	centi, c
10^{12}	tera, T	10^{-3}	milli, m
10^{9}	giga, G	10^{-6}	micro, u
10^{6}	mega, M	10^{-9}	nano, n
10^{3}	kilo, k	10^{-12}	pico, p
10^{2}	hecto, h	10^{-15}	femto, f
10^{1}	deka, da	10^{-18}	atto, a

Conversion from Non-SI-units to SI-units

Multiply # of to obtain # of	by by	to obtain # of Divide # of
	ACTIVITY	
Curies (Ci)	3.7×10^{10}	becquerels (Bq)
Ci	37	GBq
mCi	37	MBq
uCi	37	kBq
	EXPOSURE	
roentgens (R)	2.58×10^{-4}	Coulombs/kilogram (C/kg)
mR	2.58×10^{-7}	C/kg
	ABSORBED DOSE	
rads (rad)	0.01	grays (Gy)
rad	10	mGy
mrad	10	uGy
	DOSE EQUIVALENT	
rems (rem)	0.01	sieverts (Sv)
rem	10	mSv
mrem	10	uSv

APPENDIX C

MAXIMUM PERMISSIBLE CONCENTRATIONS OF RADIOISOTOPE
(Water Soluble and Only in Authorized Disposal Sinks)

Isotope	uCi/ml Water
^{82}Br	8×10^{-3}
^{109}Cd	5×10^{-3}
^{45}Ca	3×10^{-4}
^{14}C	2×10^{-2}
^{141}Ce	3×10^{-3}
^{36}Cl	2×10^{-3}
^{51}Cr	5×10^{-2}
^{57}Co	2×10^{-2}
^{60}Co	1×10^{-3}
^{3}H	1×10^{-1}
^{125}I	4×10^{-5}
^{131}I	6×10^{-5}
^{55}Fe	2×10^{-2}
^{59}Fe	2×10^{-3}
^{54}Mn	4×10^{-3}
^{203}Hg	5×10^{-4}
^{63}Ni	8×10^{-4}
^{32}P	5×10^{-4}
^{42}K	9×10^{-3}
^{22}Na	1×10^{-3}
^{85}Sr	3×10^{-3}
^{35}S	2×10^{-3}

Others Available from Radiation Safety Officer Upon Request.

UNITED STATES NUCLEAR REGULATORY COMMISSION
Washington, D.C. 20555

NOTICE TO EMPLOYEES

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

WHAT IS THE NUCLEAR REGULATORY COMMISSION?

The Nuclear Regulatory Commission is an independent Federal regulatory agency responsible for licensing and inspecting nuclear power plants and other commercial uses of radioactive materials.

WHAT DOES THE NRC DO?

The NRC's primary responsibility is to ensure that workers and the public are protected from unnecessary or excessive exposure to radiation and that nuclear facilities including power plants are constructed to high quality standards and operated in a safe manner. The NRC does this by establishing requirements in Title 10 of the Code of Federal Regulations (10 CFR) and by licenses issued to nuclear users.

WHAT RESPONSIBILITY DOES MY EMPLOYER HAVE?

Any company that conducts activities licensed by the NRC must comply with the NRC's requirements. If a company violates NRC requirements, it can be fined or have its license modified, suspended or revoked.

Your employer must tell you which NRC radiation requirements apply to your work and must post NRC Notices of Violation involving radiological working conditions.

WHAT IS MY RESPONSIBILITY?

For your own protection and the protection of your co-workers, you should know how NRC requirements relate to your work and should obey them. If you observe violations of the requirements, you should report them.

HOW DO I REPORT VIOLATIONS?

If you believe that violations of NRC rules or of the terms of the license have occurred, you should report them immediately to your supervisor. If you believe that adequate corrective action is not being taken, you may report this up on NRC inspector or the nearest NRC Regional Office.

WHAT IF I WORK IN A RADIATION AREA?

If you work with radioactive materials or in a radiation (controlled) area, the amount of radiation exposure that you may legally receive is limited by the NRC. The limits on your exposure are contained in sections 20.101, 20.103, and 20.104 of Title 10 of the Code of Federal Regulations (10 CFR 20). While these are the maximum allowable limits, your employer should also keep your radiation exposure as far below these limits as is "reasonably achievable."

MAY I GET A RECORD OF MY RADIATION EXPOSURE?

Yes. Your employer is required to tell you, in writing, if you receive any radiation exposure above the limits set in the NRC regulations at your employer's license. In addition, if your job involves radiation, you may request from your employer a record of your annual radiation exposure and a written report of your total exposure when you leave your job.

HOW ARE VIOLATIONS OF NRC REQUIREMENTS IDENTIFIED?

NRC conducts regular inspections at licensed facilities to assure compliance with NRC requirements. In addition, your employer and site contractors conduct their own inspections to assure compliance. All inspectors are protected by Federal law. Interference with them may result in criminal prosecution by a Federal attorney.

MAY I TALK WITH AN NRC INSPECTOR?

Yes. Your employer may not prevent you from talking with an NRC inspector and you may talk privately with an inspector and request that your identity remain confidential.

MAY I REQUEST AN INSPECTION?

If you believe that your employer has not corrected violations involving radiological working conditions, you may request an inspection. Your request should be addressed to the nearest NRC Regional Office and must describe the alleged violation in detail. It must be signed by you or your representative.

HOW DO I CONTACT THE NRC?

Notify an NRC inspector on site or call the nearest NRC Regional office collect. NRC inspectors want to talk to you if you are worried about radiation safety or other aspects of licensed activities, such as the quality of construction or operations at your plant.

CAN I BE FIRED FOR TALKING TO THE NRC?

No. Federal law prohibits an employer from firing or otherwise discriminating against a worker for bringing safety concerns to the attention of the NRC. You may not be fired or discriminated against because you:

- ask the NRC to enforce its rules against your employer;
- testify in an NRC proceeding;
- provide information or are about to provide information to the NRC about violations of requirements;
- are about to ask for or testify, help, or take part in an NRC proceeding.

WHAT FORMS OF DISCRIMINATION ARE PROHIBITED?

No employer may fire you or discriminate against you with respect to pay, benefits, or working conditions because you help the NRC.

HOW AM I PROTECTED FROM DISCRIMINATION?

If you believe that you have been discriminated against for bringing safety concerns to the NRC, you may file a complaint with the U.S. Department of Labor. Your complaint must describe the firing or discrimination and must be filed within 30 days of the occurrence.

Send complaints to:

Office of the Administrator
Wage and Hour Division
Employment Standards Administration
U.S. Department of Labor
Room S3502
200 Constitution Avenue, N.W.
Washington, D.C. 20210

or any local office of the Department of Labor, Wage and Hour Division. Check your telephone directory under U.S. Government Listings.

WHAT CAN THE LABOR DEPARTMENT DO?

The Department of Labor will notify the employer that a complaint has been filed and will investigate the case.

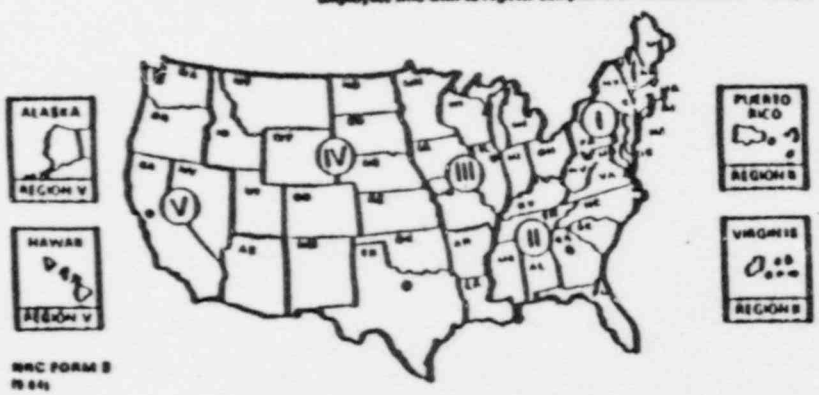
If the Department of Labor finds that your employer has unlawfully discriminated against you, it may order you to be reinstated, receive back pay, or be compensated for any injury suffered as a result of the discrimination.

WHAT WILL THE NRC DO?

The NRC may audit the Department of Labor in its investigation. NRC may conduct its own investigation where necessary to determine whether unlawful discrimination has prevented the free flow of information to the Commission. Also, if the NRC or Department of Labor finds that unlawful discrimination has occurred, the NRC may issue a Notice of Violation to your employer, impose a fine, or suspend, modify, or revoke your employer's NRC license.

UNITED STATES NUCLEAR REGULATORY COMMISSION REGIONAL OFFICE LOCATIONS

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



Regional Offices

REGION	ADDRESS	TELEPHONE
I	U.S. Nuclear Regulatory Commission Region I 631 Park Avenue King of Prussia, PA 19406	215 337 5000
II	U.S. Nuclear Regulatory Commission Region II 101 Marietta St., N.W., Suite 2900 Atlanta, GA 30323	404 221 4503
III	U.S. Nuclear Regulatory Commission Region III 799 Roosevelt Road Glen Ellyn, IL 60137	312 790 5500
IV	U.S. Nuclear Regulatory Commission Region IV 611 Ryan Plaza Drive, Suite 1000 Arlington, TX 76011	817 860 8100
V	U.S. Nuclear Regulatory Commission Region V 1450 Maria Lane, Suite 210 Walnut Creek, CA 94596	415 943 3700

NRC FORM 3
(9-83)

APPENDIX D (Actual Notice is twice this size)

APPENDIX E

ISOTOPE USE RECORD

CONTAINER

DEPARTMENT: _____ USER: _____ ACTIVITY DISPOSED: _____

COMPANY: _____ LOT#: _____ P.O.#: _____ DATE DISPOSED: _____

ISOTOPE: _____ ASSAY: (ACTIVITY) _____ DATE: RECEIVED _____ DISPOSAL METHOD: _____

DATE	ACTIVITY REMAIN*	VOLUME REMAIN*	ACTIVITY USED	VOLUME USED	HOW USED	DISPOSAL (ACTIVITY IN EACH) SINK	INCIN.	DRUM	DECAY

*REMAINING AS OF DATE INDICATED

This type form will be enclosed with your radioisotope. Please return "completed" when the package has been completely used. You should complete the heading immediately after you receive the package.

The upper right hand corner is to be filled in after the original container has been disposed.

For most people this form should be more convenient to use than the older form. Starting from the left and going across:

Date: the date of use.
Activity Remaining: the activity left in the container after considering decay and previous use.
Volume Remaining: the volume of the original material remaining (previous use should be the only reduction).
Activity Used: the activity used on the date indicated (may be multiple entrys for a given date).
Volume Used: the volume used to obtain the required activity.
How Used: eg: IP Rat, Sub Cue mouse, Inverto, etc.
Disposal:
Sink: the total activity that is expected to go down an AUTHORIZED disposal sink (water soluble only).
Incinerator: the total expected to go to the incinerator - in Animal Carcass, Waste paper, etc. (cf. EPA Radiation Safety Manual).
Decay: decay from the previous date is applicable (c^{14} decay is not applicable!)
Drum: liquids MUST BE in inner containers (vials, jugs, etc.) and enough absorbent material in the drum to absorb TWICE the amount of liquid present.

APPENDIX F

Incinerator Burning Limits

The permissible concentrations in effluents to unrestricted areas for the Animal Wing Incinerator in microcuries per hour burning time are given below. The concentrations are based on the total air flow for one hour burning time (1.84×10^9 cm^3) and the concentrations in air above natural background specified in Appendix B, Table II of the Federal Register, Title 10, Part 20. Other concentrations are available from the Radiation Safety Officer.

ISOTOPE	*AMOUNT THAT CAN BE INCINERATED PER HOUR	HALF-LIFE
Antimony (^{124}Sb)	1.28 uCi	60 days
Arsenic (^{76}As)	5.52 uCi	26.6 hours
(^{77}As)	18.40 uCi	38.8 hours
Barium (^{131}Ba)	18.40 uCi	11.6 days
Bismuth (^{210}Bi)	0.38 uCi	5.0 days
Bromine (^{82}Br)	11.00 uCi	35.9 hours
Cadmium (^{109}Cd)	3.67 uCi	1.3 years
Cadmium (^{115m}Cd)	1.84 uCi	43 days
Calcium (^{45}Ca)	1.84 uCi	164 days
(^{47}Ca)	10.96 uCi	4.7 days
Carbon (^{14}C)	184.00 uCi	5570 years
Cerium (^{141}Ce)	9.20 uCi	32.5 days
Cesium (^{134}Cs)	0.73 uCi	2.3 years
(^{136}Cs)	10.96 uCi	13.5 days
(^{137}Cs)	3.67 uCi	30 years
Chlorine (^{36}Cl)	1.45 uCi	3.2×10^5 years
Chromium (^{51}Cr)	147.20 uCi	27.8 days
Cobalt (^{57}Co)	10.96 uCi	270 days
(^{60}Co)	0.55 uCi	5.27 years
Copper (^{64}Cu)	73.60 uCi	12.8 hours
Gold (^{198}Au)	14.72 uCi	65 hours
Hydrogen (^{3}H, tritium)	368.00 uCi	12.5 years

ISOTOPE	*AMOUNT THAT CAN BE INCINERATED PER HOUR	HALF-LIFE
Iodine (^{125}I)	0.15 uCi	60 days
(^{129}I)	0.06 uCi	1.6×10^7 years
(^{131}I)	0.21 uCi	8 days
Iron (^{55}Fe)	55.20 uCi	2.94 years
(^{59}Fe)	3.67 uCi	45 days
Manganese (^{52}Mn)	9.20 uCi	5.6 days
(^{54}Mn)	1.84 uCi	300 days
Mercury (^{197}Hg)	73.60 uCi	65 hours
(^{203}Hg)	3.67 uCi	47 days
Nickel (^{63}Ni)	3.67 uCi	125 years
Phosphorus (^{32}P)	3.67 uCi	14.3 days
Potassium (^{42}K)	73.60 uCi	12.7 hours
Rubidium (^{86}Rb)	3.67 uCi	18.6 days
Silver (^{111}Ag)	14.64 uCi	7.5 days
Sodium (^{22}Na)	0.55 uCi	2.6 years
(^{24}Na)	9.20 uCi	15 hours
Strontium (^{90}Sr)	0.06 uCi	28 years
Sulfur (^{35}S)	16.48 uCi	88 days
Yttrium (^{90}Y)	5.52 uCi	64.2 hours
Zinc (^{65}Zn)	3.67 uCi	245 days

*Amounts are also limits for each package.

APPENDIX G

INCINERATION RECORD FORM* MONTH _____ 19 ___ LOCATION _____

Day	ISO	AMT	SIG	Day	ISO	AMT	SIG	Day	ISO	AMT	SIG	Day	ISO	AMT	SIG
1				9				17				25			
2				10				18				26			
3				11				19				27			
4				12				20				28			
5				13				21				29			
6				14				22				30			
7				15				23				31			
8				16				24							

ISO - Isotope
AMT - Amount incinerated in microcuries (uCi)
SIG - Signature of responsible individual

*To be completed by the incinerator operator.

APPENDIX H

APPLICATION FOR USE OF RADIONUCLIDES

THIS FORM MUST BE COMPLETED AND APPROVED PRIOR TO PURCHASING RADIONUCLIDES FOR USE IN AN EXPERIMENT. THE RADIATION SAFETY OFFICER MUST BE NOTIFIED PRIOR TO ANY CHANGE IN TECHNIQUE, RADIONUCLIDE, OR PERSONNEL INVOLVED IN THIS EXPERIMENT.

(Please Type)

PART A: PERSONNEL

Principal Investigator: _____ Date: _____

Laboratory Location: _____ Phone No: _____

If investigator already has approval by the AWBERC Radiation Safety Committee to use radioactive material, give the date that approval was first given: _____. If this is the initial application for use of radioactive material at AWBERC, describe previous experience in the safe handling of radiation by principal investigator and all other involved personnel; (include names, dates, location, radionuclide(s), amount of radionuclide(s), training, etc.)

_____

_____

_____

_____

_____

Personnel with no previous experience must enroll in the Radiation Safety Course. Give the names of those who wish to enroll in the next Radiation Safety Course:

_____

_____

IT IS A REQUIREMENT BOTH OF THE EPA AND OF OUR NRC BROAD LICENSE THAT EACH WORKER WITH RADIATION MUST READ AND UNDERSTAND THE AWBERC RADIATION SAFETY MANUAL. FAILURE OF YOU OR YOUR PERSONNEL TO COMPLY MAY RESULT IN TERMINATION OF PRIVILEGE OF USING RADIOACTIVE MATERIAL.

Do you have a copy of the AWBERC Radiation Safety Manual? _____

Have you read and do you understand this Safety Manual? _____

Have the other personnel involved in this radiation work read and do they understand this Safety Manual? _____

APPENDIX H (Continued)

PART B: EXPERIMENTAL PLAN

Title of Experiment:

Starting Date: Expected Date of Completion:

Bldg. and Room Where Radiation Will be Handled:

Radionuclide(s)	Activity Per Purchase	Per Each Use

The investigator is responsible, and must be equipped, for laboratory survey of possible contamination with survey meter and wipe tests. Frequency of survey and wipe tests depends upon amount of radionuclide used, its relative hazard, and the type of experiment conducted.

How often will survey and wipe tests be performed? (daily, weekly, after each use, etc.)

Where is survey meter located? (Bldg. and Room)
Manufacturer: Model:
Serial Number:

IT IS THE INVESTIGATOR'S RESPONSIBILITY THAT THIS SURVEY METER BE CALIBRATED AT LEAST ANNUALLY.

If radioactive material is volatile, air sampling for contamination is required. Do you expect airborne contamination? If so, describe apparatus and procedure for air sampling:

Do you and your involved personnel have film badges?

Solid Waste Disposal Procedure:
Liquid Waste Disposal Procedure:
Do you have an authorized disposal sink? Sink Number:

Have radioactive materials been used in this location before?

Attach a separate one page description of experiment detailing the step-by-step handling of the radioactivity from the time it is received to the time it is disposed of emphasizing safety techniques, e.g. gloves, shields, remote handling devices, etc. will be used. DO NOT ATTACH A LENGTHY RESEARCH PROPOSAL WITH INFORMATION NOT PERTINENT TO RADIATION SAFETY!

Signature of Principal Investigator:

APPENDIX I

RADIATION SAFETY

RADIOACTIVE WASTE CONTAINER LOG

CONTAINER NO. _____ TYPE CONTAINER _____
(Description and Size)

LOCATION _____
(Room and/or Area) (Building)

DATE	ISOTOPE	TYPE OF WASTE	AMOUNT	RADIATION LEVEL	DISPOSED BY

I certify there is enough absorbent material contained in this drum to absorb twice the amount liquid present.

NAME _____ DATE _____

EPA-296 (Cin)
(2-77)

APPENDIX J

CERTIFICATION FOR USE OF RADIATION

Original must be filed with the Radiation Safety Committee. A copy will be returned to the individual completing this form. This form must be completed before beginning work with radiation.

NAME _____ DATE OF BIRTH _____ SEX ☐ M ☐ F

HOME ADDRESS _____ HOME PHONE _____

TITLE _____

LOCATION OF LABORATORY _____ PHONE _____

LOCATION OF OFFICE _____ PHONE _____

SUPERVISOR _____

I wish to enroll in the next radiation safety class ☐

I certify that I have received instruction in the safe use of radiation, that I have read and understand the Environmental Protection Agency Radiation Safety Manual and the regulations of the U.S. Nuclear Regulatory Commission.

DATE _____ _____
SIGNED

Applicant certified by: Completing Course on _____
date

By previous training ☐

Per _____ _____
(Radiation Safety Officer) (date)

FOR INDIVIDUALS HAVING PREVIOUS RADIATION EXPERIENCE:

APPLICANT HAS HAD ADEQUATE TRAINING AND EXPERIENCE AT _____

from _____ to _____ under the supervision of _____

_____
(Name and Title)

(NOTE:) You are required to read and understand the Environmental Protection Agency Radiation Safety Manual and regulations of the NRC.

The original of this form is to be sent to the Safety/Security Office, Attn: Radiation Safety Committee, before beginning work with radiation.

EPA-294 (Cin)
(2-77)

U.S. NUCLEAR REGULATORY COMMISSION

APPENDIX TO REGULATORY GUIDE 8.13

POSSIBLE HEALTH RISKS TO CHILDREN OF WOMEN WHO ARE EXPOSED TO RADIATION DURING PREGNANCY

Some recent studies have shown that the risk of leukemia and other cancers in children increases if the mother is exposed to a significant amount of radiation during pregnancy. According to a report by the National Academy of Sciences, the incidence of leukemia among children from birth to 10 years of age in the United States could rise from 3.7 cases in 10,000 children to 5.6 cases in 10,000 children if the children were exposed to 1 rem of radiation before birth (a "rem" is a measure of radiation). The Academy has also estimated that an equal number of other types of cancers could result from this level of radiation. Although other scientific studies have shown a much smaller effect from radiation, the Nuclear Regulatory Commission wants women employees of its licensees to be aware of any possible risk so that the women can take steps they think appropriate to protect their offspring.

As an employee of a Nuclear Regulatory Commission licensee, you may be exposed to more radiation than the general public. However, the Nuclear Regulatory Commission has established a basic exposure limit for all occupationally exposed adults of 1.25 rems per calendar quarter, or 5 rems per year. No clinical evidence of harm would be expected in an adult working within these levels for a lifetime. Because the risks of undesirable effects may be greater for young people, individuals under 18 years of age are permitted to be exposed to only 10 percent of the adult occupational limits. (This lower limit is also applied to members of the general public.)

The scientific organization called the National Council on Radiation Protection and Measurements has recommended that because unborn babies may be more sensitive to radiation than adults, their radiation dose as a result of occupational exposure of the mother should not exceed 0.5 rem. Other scientific groups, including the International Commission on Radiation Protection, have also stressed the need to keep radiation doses to unborn children as low as is reasonably achievable.

All Nuclear Regulatory Commission licensees are now required* to inform all individuals who work in a restricted area of the health protection problems associated with radiation exposure. This instruction would in many cases include information on the possible risks to unborn babies. The regulations also state** that licensees should keep radiation exposures as low as is reasonably achievable. According to the National Council on Radiation Protection and Measurements, vigorous efforts should be made to keep the radiation exposure of an embryo or fetus at the very lowest practicable level during the entire period of pregnancy.

Thus it is the responsibility of your employer to take all practicable steps to reduce your radiation exposure. Then it is your responsibility to decide whether the exposure you are receiving is sufficiently low to protect your unborn child. The advice of your employer's health physicist or radiation protection officer should be obtained to determine whether radiation levels in your working areas are high enough that a baby could receive 0.5 rem or more before birth. If so, the alternatives that you might want to consider are:

(a) If you are now pregnant or expect to be soon, you could decide not to accept or continue assignments in these areas.

(b) You could reduce your exposure, where possible, by decreasing the amount of time you spend in the radiation area, increasing your distance from the radiation source, and using shielding.

(c) If you do become pregnant, you could ask your employer to reassign you to areas involving less exposure to radiation. If this is not possible, you might consider

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* By Title 10, Part 19 of the Code of Federal Regulations.

**In Title 10, Part 20.

leaving your job. If you decide to take such steps, do so without delay. The unborn child is most sensitive to radiation during the first three months of your pregnancy.

(d) You could delay having children until you are no longer working in an area where the radiation dose to your unborn baby could exceed 0.5 rem.

You may also, of course, choose to:

(e) Continue working in the higher radiation areas, but with full awareness that you are doing so at some small increased risk for your unborn child.

The following facts should be noted to help you make a decision:

1. The first three months of pregnancy are the most important, so you should make your decision quickly.

2. In most cases of occupational exposure, the actual dose received by the unborn baby is less than the dose received by the mother because some of the dose is absorbed by the mother's body.

3. At the present occupational exposure limit, the actual risk to the unborn baby is small, but experts disagree on the exact amount of risk.

4. There is no need to be concerned about sterility or loss of your ability to bear children. The radiation dose required to produce such effects is more than 100 times larger than the Nuclear Regulatory Commission's dose limits for adults.

5. Even if you work in an area where you receive only 0.5 rem per three-month period, in nine months you could receive 1.5 rems, and the unborn baby could receive more than 0.5 rem, the full-term limit suggested by the NCRP. Therefore, if you decide to restrict your unborn baby's exposure as recommended by the NCRP, be aware that the 0.5 rem limit to the unborn baby applies to the full nine-month pregnancy.

The remainder of this document contains a brief explanation of radiation and its effects on humans. As you will see, some radiation is present everywhere and the levels of radiation most employees of Nuclear Regulatory Commission licensees receive are not much larger than these natural levels. Because the radiation levels in the facility where you will be working are required by law to be kept quite low, there is not considered to be a significant health risk to individual adult employees.

Discussion of Radiation

The amount of radiation an individual receives called the "dose" and is measured in "rems." The average individual in the United States accumulates a dose of one rem from natural sources every 12 years. The dose from natural radiation is higher in some states, such as Colorado, Wyoming, and South Dakota, primarily because of cosmic radiation. There the average individual gets one rem every 8 years.

Natural background radiation levels are also much higher in certain local areas. A dose of one rem may be received in some areas on the beach at Guarapari, Brazil, in only about 9 days, and some people in Kerala, India, get a dose of one rem every 3 months.

Many people receive additional radiation for medical reasons. In 1970, an estimated 212 million X-ray examinations were performed in the United States. The estimated average surface skin dose from one radiographic chest X-ray is 0.027 rem. The estimated average surface skin dose per abdominal X-ray is 0.62 rem.*

Radiation can also be received from natural sources such as rock or brick structures, from consumer products such as television and glow-in-the-dark watches, and from air travel. The possible annual dose from working 8 hours a day near a granite wall at the Hedcap Stand in Grand Central Station, New York City, is 0.[illegible] rem, and the average annual dose in the United States from TV, consumer products, and air travel is 0.002[illegible] rem.

Radiation, like many things, can be harmful. A large dose to the whole body (such as 600 rems in one day) would probably cause death in about 30 days, but such large doses result only from rare accidents. Control of exposure to radiation is based on the assumption that any exposure, no matter how small, involves some risk. The occupational exposure limits are set so low, however, that medical evidence gathered over the past 50 years indicates no clinically observable injuries to individuals due to radiation exposures when the established radiation limits are not exceeded. This was true even for exposures received under the early occupational exposure limits, which were many times higher than the present limits. Thus the risk to individuals at the occupational exposure levels is considered to be very low. However, it is impossible to say that the risk is zero. To decrease the risk still further, licensees are expected to keep actual exposures as far below the limits as is reasonably achievable.

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*"Pre-Release Report: X-Ray Exposure Study (XES) Revised Estimates of 1964 and 1970 Genetically Significant Dose," February 4, 1975, U.S. Department of Health, Education and Welfare, Public Health Service, Federal Drug Administration, Bureau of Radiological Health.

The current exposure limits for people working with radiation have been developed and carefully reviewed by nationally and internationally recognized groups of scientists. It must be remembered, however, that these limits are for adults. Special consideration is appropriate when the individual being exposed is, or may be, an expectant mother because the exposure of an unborn child may also be involved.

Prenatal Irradiation

The prediction that an unborn child would be more sensitive to radiation than an adult is supported by observations for relatively large doses. Large doses delivered before birth alter both physical development and behavior in experimentally exposed animals. A report of the National Academy of Sciences states that short-term doses in the range of 10 to 20 rems cause subtle changes in the nerve cells of unborn and infant rats. The report also states, however, that no radiation induced changes in development have been demonstrated to result in experimental animals from doses up to about 1 rem per day extended over a large part of the period before birth.

The National Academy of Sciences also noted that doses of 25 to 50 rems to a pregnant human may cause growth disturbances in her offspring. Such doses substantially exceed, of course, the maximum permissible occupational exposure limits.

Concern about prenatal exposure (i.e., exposure of a child while in its mother's uterus) at the permissible occupational levels is primarily based on the possibility that cancer (especially leukemia) may develop during the first 10 years of the child's life. Several studies have been performed to evaluate this risk. One study involved the follow-up of 77,000 children exposed to radiation before birth (because of diagnostic abdominal X-rays made for medical purposes during their mother's pregnancy). Another study involved the followup of 20,000 such children. In addition, 1292 children who received prenatal exposure during the bombing of Hiroshima and Nagasaki were studied. Although contradictory results have been obtained, most of the evidence suggests a relationship between prenatal exposure and an increased risk of childhood cancer.

Summary

Occupational exposures to radiation are being kept low. However, qualified scientists have recommended that the radiation dose to an embryo or fetus as a result of occupational exposure of the expectant mother should not exceed 0.5 rem because of possible increased risk of childhood leukemia and cancer. Since this 0.5 rem is lower than the dose generally permitted to adult workers, women may want to take special actions to avoid receiving higher exposures, just as they might stop smoking during pregnancy or might climb stairs more carefully to reduce possible risks to their unborn children.

Bibliography

1. Donald G. Pizzarello and Richard L. Witcofski, *Basic Radiation Biology*, Philadelphia: Lea and Febiger, 1967.

2. National Academy of Sciences – National Research Council, *The Effects on Populations of Exposure to Low Levels of Ionizing Radiation*, Washington, D.C., November 1972.

3. National Council on Radiation Protection and Measurements, *Basic Radiation Protection Criteria*, NRCP Report No. 39, Washington, D.C., January 5, 1971.

4. United Nations, *Ionizing Radiation: Levels and Effects*, 2 vol., Reports of the United Nations Scientific Committee on the Effects of Atomic Radiation, Report No. A/8725, United Nations, New York, 1972.

5. U.S. Atomic Energy Commission, Division of Technical Information, Understanding the Atom Series:

   Atoms, Nature and Man

   The Genetic Effects of Radiation

   The Natural Radiation Environment

   Your Body and Radiation

APPENDIX L

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
CINCINNATI, OHIO 45268

DATE: November 25, 1985

SUBJECT: Development of AWBERC Policy on the Use of Individuals (Less Than 18 Years of Age) with Radioactive Material

FROM: Carl Rybak, Health and Safety Officer
Chemical and Statistical Support Branch, TMD, HERL

TO: Louis Lefke, Chairperson
Radiation Safety Committee

THRU: Elmer W. Akin, Acting Director
Toxicology and Microbiology Division, HERL

The recommended AWBERC policy on the subject of age requirements for working with radioisotopes is as follows:

- No individual under 18 years of age shall be occupationally exposed to radioactive material.
- No individual under 18 years of age shall work with radioisotopes.
- Persons under 18 years who are students in an education program are allowed to work in the same laboratory area where certified personnel are handling radioisotopes. However, they must be notified of the possible hazard and must be at a safe distance from the radioactive material in order to insure that they will not be exposed to a radiation hazard if an accident occurred.