

BOEHRINGER MANNHEIM DIAGNOSTIC  
RADIATION SAFETY MANUAL

Purpose

Rules & Regulations

10 CFR Part 19

10 CFR Part 20

Regulatory Guide 8.10

ALARA Implementation Letter

Form NRC 3

8509110224 850801  
REG3 LIC30  
13-24532-01 PDR

CONTROL NO. 7 928 1

BOEHRINGER MANNHEIM DIAGNOSTIC

RADIATION SAFETY MANUAL

PURPOSE:

This manual is provided to the employee in line with the management's philosophy of minimizing radiation exposure to employees to that which is as low as is reasonably achievable.

This manual will provide the employee with the rules and regulations governing the use of radioactive material within Boehringer Mannheim Diagnostics. In addition, Regulatory Guidelines and Regulations of the Nuclear Regulatory Commission are also provided.

The company can and will provide the necessary equipment and environment to insure that exposure to radiation is reduced, but it also requires your attention and cooperation for this program to be effective. This manual is given for your information and personal use.

In addition, the Radiation Safety Officer, is available for questions. You have the right to see copies of the Nuclear Regulatory Commission licenses that allow us to use radioactive material. You also have the right to all NRC inspection reports and reports of any defects found. You will also have available copies of the most recent film badge reports for your inspection.

RADIATION SAFETY MANUAL

POLICY, PROCEDURES AND REGULATIONS

FOR

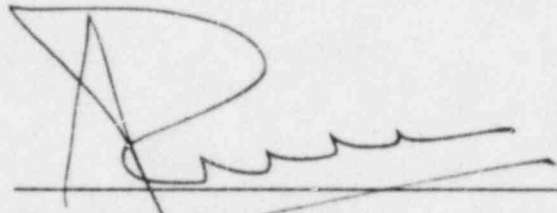
BOEHRINGER MANNHEIM DIAGNOSTICS

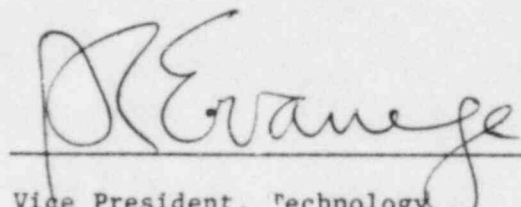
INDIANAPOLIS, INDIANA

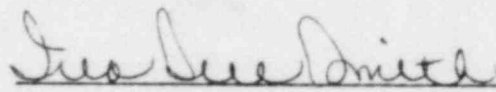
CONTROL NO. 7 928 1

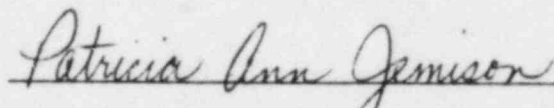
RADIATION SAFETY MANUAL

APPROVAL:

 6/24/85  
\_\_\_\_\_  
Chief Executive Officer

 6/24/85  
\_\_\_\_\_  
Vice President, Technology

 6/21/85  
\_\_\_\_\_  
Manager, Regulatory Affairs

 6/21/85  
\_\_\_\_\_  
Radiation Safety Officer

Revision date: June 10, 1985



## TABLE OF CONTENTS

	<u>Page</u>
1.0 THE RADIATION SAFETY COMMITTEE	1
2.0 THE RADIATION SAFETY OFFICER	2
3.0 LICENSING REGULATIONS	3
4.0 PROCUREMENT OF RADIOACTIVE MATERIAL	5
5.0 TYPES OF AREAS	6
6.0 PROPER LABELING PROCEDURES	7
7.0 PERSONNEL MONITORING	7
8.0 LAB MONITORING AND SURVEYS	9
9.0 RULES FOR THE SAFE HANDLING OF RADIOACTIVE MATERIALS	10
10.0 RADIOACTIVE WASTE DISPOSAL	13
11.0 EMERGENCY PROCEDURES	15
12.0 PACKAGING AND TRANSPORTING RADIOACTIVE MATERIALS	18

### Appendices

1. Control Procedure No. 6
2. Appendix C, 10 CFR Part 20
3. Request for Film Badge Service Form
4. Decontamination Methods for Various Surface Types
5. Abbreviated Packaging and Transporting Requirements

## 1.0 THE RADIATION SAFETY COMMITTEE

### 1.1 Purpose

The purpose of the Radiation Safety Committee is to ensure that all use of radioactive material within Boehringer Mannheim Diagnostics Group is conducted in a safe manner and in accordance with Nuclear Regulatory Commission (NRC) regulations and the conditions of the license.

### 1.2 Authority

The Committee is approved by the President of the Division.

### 1.3 Meeting Frequency

The Committee shall meet as often as necessary to conduct its business, but not less than once in each calendar quarter.

### 1.4 Responsibilities of the Radiation Safety Committee

The Committee shall:

1. Be familiar with all pertinent NRC regulations, the terms of the license, and the information submitted in support of the request for the license and its amendments.
2. Review the training and experience of any individual who uses radioactive material and determine that the qualifications are sufficient to enable them to perform their duties safely and in accordance with NRC regulations and the conditions of the license.
3. Establish a program to ensure that all individuals whose duties may require them to work in the vicinity of radioactive material (e.g., warehouse and housekeeping personnel) are properly instructed as required by Section 19.12, of 10 CFR Part 19.
4. Review and approve all requests for use of radioactive material within the institution.
5. Prescribe special conditions that will be required during a proposed use of radioactive material such as requirements for bioassays, physical examinations of users and special monitoring procedures.
6. Review the entire radiation safety program at least annually to determine that all activities are being conducted safely and in accordance with NRC regulations and the conditions of the license. The review shall include an examination of all records, reports from the radiation safety officer, results of NRC inspection, written safety procedures and management control system.

7. Recommend remedial action to correct any deficiencies identified in the radiation safety program.
8. Maintain written records of all committee meetings, actions, recommendations, and decisions.
9. Ensure that the byproduct material license is amended, when necessary, prior to any changes in facilities, equipment, policies, procedures, and personnel.

#### 1.5 Membership

Membership shall be Director of QA and RA, Radiation Safety Officer, Assistant Radiation Safety Officer, Receiving Department Supervisor, Microbiology/Immunology Production Supervisor, Analytical Services Supervisor, Shipping Supervisor, and other individuals listed on the materials license as users of licensed materials.

#### 1.6 Quorum and Voting Requirements

1. A quorum shall consist of a majority of the Committee membership.
2. A unanimous vote of the members present shall be required for approval. A dissenting vote will commit the dissenter to a proposal for further study.

### 2.0 THE RADIATION SAFETY OFFICER (RSO)

#### 2.1 Authority

The Radiation Safety Officer derives authority from the President of the Division regarding measures to implement radiation protection and control within Boehringer-Mannheim Diagnostic Group.

The Radiation Safety Officer shall have the authority to immediately suspend any procedures involving radioactive materials which endanger health or property.

#### 2.2 Responsibilities of the Radiation Safety Officer are:

1. Provide consulting services on all aspects of radiation protection.
2. Maintain radiation exposures As Low As Reasonably Achievable by the supervision or operation of an effective and appropriate radiation protection and control program.
3. To disseminate information concerning radiation safety and health physics and to initiate and maintain programs to educate users in the safe handling of radioactive materials, and to ensure that all individuals whose duties may require them to work in the vicinity of radioactive material (e.g., warehouse and housekeeping personnel) are properly instructed as required by Section 19.12 of 10 CFR Part 19.

4. Monitor ordering and receiving of radioactive materials and audit records pertinent thereto. To provide Shipping and Receiving with Control Procedures.
5. To provide personnel monitoring for appropriate individuals and to maintain personnel exposure records.
6. To perform periodic and special radiation protection surveys of all areas where radioactive materials are utilized or stored and to keep of these surveys.
7. To review all proposals for usage of radioactive material.
8. To inspect facilities and equipment to be used in conjunction with radioactive materials.
9. To approve construction and remodeling of facilities intended for radioactive material usage.
10. To supervise disposal of radioactive waste and to keep records of such.
11. To perform periodic leak testing of sealed sources.
12. To obtain and maintain all required licenses and registrations for use of radioactive material by Boehringer Mannheim Diagnostic Group.

### 3.0 LICENSING REGULATIONS

#### 3.1 Government Regulations

By product radioactive material may be used only under specific or general licenses issued by the United States Nuclear Regulatory Commission. The regulations covering the procurement of licenses are published in Title 10, of the code of Federal Regulations. We also operate under Indiana Regulations HRH-2 (6-25-78), Regulation for Radiation Control. Copies of these regulations are available from the Radiation Safety Officer.

All licensees of the Nuclear Regulatory Commission are required to conform with standards for protection against radiation established by the NRC. These regulations are published in Title 10, Parts 19 and 20 of the Code of Federal Regulations. Copies of these standards may be obtained from the Radiation Safety Officer.

#### 3.2 Boehringer Mannheim Diagnostics Group Regulations

No persons may use within, or bring into Boehringer Mannheim Diagnostics Group any radioisotopes in amounts which would ordinarily require a specific license from the Nuclear Regulatory Commission without authorization from the Radiation Safety Officer.

### 3.3 Responsibilities of approved Users are:

1. Compliance with all rules for the safe handling of radioactive material and the applicable state and federal regulations.
2. Instructions of employees under their control in the use of safety devices and procedures.
3. Adequate planning of an experiment, procedure, or production to assure that adequate safety precautions are taken.
4. Keeping the RSO informed of new techniques, changes in operational procedures, or in the physical facilities which might lead to increased personnel exposure or contamination levels in the laboratory or surrounding environment.
5. Direction of all personnel under their control to comply with all recommendations which are designed to control and reduce their total exposure.
6. Limitation of use of radioactive material under his permit to those over whom he has direct supervision.
7. Maintenance of required current records of receipt use, storage and disposal of radioactive material, and records of laboratory surveys.
8. Arrange for film badge service for persons under his control when such coverage is required.
9. The Approved User shall jointly bear the responsibility with female employees under his supervision to immediately report any pregnancy or suspected pregnancy of personnel involved with the handling of radioactive material. This is to allow for proper exposure limitation and monitoring of such personnel by the RSO.

### 3.4 Responsibility of the Individual User of Radioactive Materials

Each person at Boehringer Mannheim Diagnostic Group who uses radioactive material has a responsibility to:

1. Keep his exposure As Low As Reasonably Achievable and below the maximum permissible exposure (100 mR/wk).
2. Wear the recommended radiation detector for personnel monitoring.
3. Maintain good housekeeping practices in the laboratory.
4. Be aware of and work in compliance with Federal, State and Company regulations concerning the safe use of radioactive sources (must read the Radiation Safety Manual).



5. Survey his person for radioactivity and remove all loose contamination before leaving the laboratory.
6. Use all recommended radiation safety protective measures.
7. Avoid smoking, eating or drinking in laboratories where radionuclides are stored or manipulated.
8. Check work areas for contamination after carrying out procedures involving radionuclides.
9. Label contaminated equipment and segregate radioactive waste and equipment to avoid cross contamination.
10. Report spills or accidents involving radioactive material immediately to Radiation Safety Officer.
11. Conduct appropriate decontamination procedures when necessary, under the supervision of the Radiation Safety Officer or his appointed personnel.
12. Maintain required records of receipt, use, storage and disposal of radionuclides, and records of laboratory surveys.

#### 4.0 PROCUREMENT OF RADIOACTIVE MATERIAL

##### 4.1 Requisitions

1. All requisitions for the purchase of radioactive material must be initiated by an approved user. A list of approved users will be supplied to the Purchasing Agent responsible for the purchase of radionuclides by the Radiation Safety Officer.
2. The instructions are to be observed in Control Procedure No. 6 for all incoming shipments of radioactive materials. See Appendix 1.

##### 4.3 Procedure for Opening Packages Containing Radioactive Material

1. Packages containing non-exempt quantities of radioactive material labeled according to Control Procedure Number 6 in Appendix 1 are to be opened only by authorized individuals.
2. Individual opening package must wear protective clothing and gloves.
3. Note external condition of package and record on package receipt form. If package is wet or stained, immediately wipe test the package surface with filter paper and forceps. Assay the filter paper in a scintillation crystal detector system (for gamma emitters) or in a liquid scintillation counting system (for beta emitters). If counts are above 22,000 dpm, notify Radiation Safety Officer and do not open package. Record wipe test result.

4. Packages containing tritium, carbon-14, sulfur-35 or other low energy beta emitters in quantities exceeding those in Appendix 2 must be wipe tested. Assay the filter paper in a liquid scintillation counter and record results.
5. All packages (except those containing carbon-14, tritium or other low energy beta emitters) must be surveyed for radioactive contamination with a GM meter prior to opening. Record results.
  - a) Measure exposure rate at 3 feet from package surface with thin window GM detector. If this reading is  $> 10$  mR/h, immediately notify the Radiation Safety Officer and do not open the package.
  - b) Measure exposure rate at package surface with thin window GM Detector. If this reading is  $> 200$  mR/h, proceed as in Step a) (above).
6. Carefully open outer shipping container and remove the radionuclide. Measure the exposure rate at the surface of the empty shipping container and record result. If this reading is greater than 2x background, then final radioactive container must be wipe tested and the results recorded.
  - a) Wipe test with filter paper using forceps. Assay the filter paper with a scintillation crystal detector system. If counts above 22,000 dpm, notify Radiation Safety Officer.
7. After package has been surveyed, complete the remaining sections on the package receipt form.
8. If package and/or packing material are contaminated, treat as radioactive waste. If not, obliterate radiation warning labels and discard as regular trash.

## 5.0 TYPES OF AREAS

### 5.1 Restricted Area

Any area access to which is controlled for purposes of radiation protection of individuals from exposure to radiation and radioactive materials.

### 5.2 Unrestricted Area

Any area access to which is not controlled for purposes of protection of individuals from exposure to radiation and radioactive materials.

## 6.0 PROPER LABELING PROCEDURES

- 6.1 The Radiation Safety Officer shall assume responsibility for providing appropriate signs for posting in laboratories, production areas and any other areas where radioactivity is stored or used. Laboratory personnel are responsible for labeling containers and other equipment and apparatus in which radioactive materials are used or are stored within the lab.
- 6.2 All areas in which radioactive materials are used or stored are to be properly labeled in accordance with 10 CFR Part 20.203 and as such are restricted from entrance by unauthorized personnel (Restricted Areas). The radiation symbol prescribed is the conventional three bladed design and shall employ the colors magenta (or purple) on yellow.
  1. An area in which a major portion of the body could receive a dose in excess of 5 mRem must display a sign bearing the radiation symbol and the words "CAUTION: RADIATION AREA".
  2. An area in which a major portion of the body could receive in any one hour a dose in excess of 100 mRem must display a sign bearing the radiation symbol and the words "CAUTION: HIGH RADIATION AREA".
- 6.3 Each container in which radioactive material is transported, stored or used (in quantities equal to or exceeding those in Appendix 2) shall bear a durable, clearly visible label with the radiation symbol and the words "CAUTION: RADIOACTIVE MATERIAL". When such containers are used for storage, the labels must also contain a statement of the quantity and kind of radioactive material present as well as the date on which such a quantity was present.

## 7.0 PERSONNEL MONITORING

### 7.1 Rationale

If an individual receives or is likely to receive in any calendar quarter a dose of radiation in excess of 25% of the maximum permissible dose, he is required by the NRC to be subject to personnel monitoring.

### 7.2 Maximum Permissible Doses

1. The maximum permissible doses in rem per calendar quarter for individuals working in restricted areas are as follows:

Whole body, head and trunk, active blood forming organs, gonads and lens of the eye...	1-1/4 rem
Hands, forearms, feet and ankles...	18-3/4 rem
Skin of the whole body...	7-1/2 rem
2. Doses to the whole body, etc., of individuals in excess of 1-1/4 rem per quarter are permitted only if the dose does not exceed 3 rem during the quarter and that the cumulative (lifetime) dose does not exceed 5(N-18) rem where N equals age in years.



3. The maximum exposure to individuals under the age 18 must not exceed 1/10 of the limits given above (e.g., 0.125 rem for exposure to the whole body, etc.).
4. In the case of occupational exposure of women of child-bearing age, the controlling factor is the need to minimize the exposure to an embryo or fetus. The maximum dose to an expectant mother should not exceed 0.5 rem during the entire gestation period of the fetus. It is for this reason that known or suspected pregnancies in women working with radioactive materials or radiation producing sources and/or devices must be reported immediately to the Radiation Safety Officer.
5. The maximum permissible dose for individuals in unrestricted areas is 500 millirem to the whole body in any period of one calendar year, which corresponds to 10 millirem/week. If it can be shown that no nonoccupationally exposed individual could receive in excess of 500 millirem in one year, radiation levels higher than 10 millirem/week are permitted in a given unrestricted area, but the dose to the whole body must not exceed 2 millirem in one hour or 100 millirem in one week.
6. In all cases, every effort must be made to keep the radiation exposure to all individuals As Low As Reasonably Achievable.

### 7.3 Methodology

1. Personnel monitoring will usually take the form of film badges which are to be worn on the chest or waist. They shall be mandatory for all individuals working in restricted areas. When the hand dose may exceed 25% of the relevant limit, ring or wrist badges must be worn. (See Appendix 3- Request for Film Badge Service).
2. In areas where the nature of the radiation or the level of exposure may be unusual (e.g. High Radiation Area), personnel monitors of the ionization type should be worn and the readings recorded daily.
3. When deemed necessary by the Radiation Safety Officer, bio-assay procedures, such as urinalysis or breath analysis, may be instituted.
4. The film badge is not to be worn when the individual is undergoing diagnostic or therapeutic radiation exposure.
5. When not in use, the film badge should be stored in a location away from radiation, excessive heat and moisture.
6. In the absence of evidence to the contrary, missing films will be treated as having received the fraction of the maximum permissible dose proportional to the time period in question.
7. When a personnel radiation monitoring film is lost, immediately notify the Radiation Safety Officer. A new radiation monitoring film will then be issued so that personnel monitoring may continue without interruption.

8. Personnel radiation monitoring films are not to be worn except by the person whose name appears on the film packet. Visitor dosimeters are available from the Radiation Safety Officer upon request to monitor visitors, new personnel, and for individuals who have lost a previously issued badge.
9. Upon termination of employment at Boehringer Mannheim Diagnostic Group, the radiation monitoring film and film holder must be returned to the Radiation Safety Officer.

#### 7.4 Records and Reports

1. Permanent records of film badge exposure will be kept by the Radiation Safety Officer. Copies of such reports will be distributed monthly, by department, to departments having monitored individuals.
2. In any instance where an individual's monthly exposure exceeds 200 mrem, the Radiation Safety Officer will notify the individual or his supervisor in writing as a means of alerting the individual to the occurrence of the exposure.
3. In accordance with 10 CFR Part 19, the Radiation Safety Officer will provide an individual with a copy of his permanent occupational exposure history upon written request. Likewise, records of exposure will be forwarded to new employers upon written request of the individual.

### 8.0 LAB MONITORING AND SURVEYS

#### 8.1 Area Monitors

Areas in which sealed or unsealed sources may give rise to radiation levels such that a whole body exposure in excess of 5 mR in one hour is possible, are required to have on hand and in operating condition a calibrated monitoring instrument capable of measuring the exposure or dose rate for the type and energy of the radiation in use.

#### 8.2 Portable Survey Meters

Except in instances in which low levels of very low energy radionuclides are used and with the previous approval of the Radiation Safety Officer, laboratories using unsealed sources are required to have on hand and in operating condition a sensitive survey instrument capable of detecting the presence of the radionuclide in use when the radionuclide is brought, unshielded, in close proximity to the detector. An absolute calibration shall not be required for such a meter, except that it shall be capable of detecting 0.05 microcuries ( $10^5$  DPM) of the radionuclide in question.

1. The survey meter shall be used frequently during and following work with radioactive materials to determine the presence of radioactivity on working surfaces, the body and clothing.

2. All survey meters used routinely in the radiation safety program must be calibrated at least annually. Calibration will be performed by the Radiation Safety Officer or outside service. Each user may bring his survey instrument to the Radiation Safety Officer and request calibration at any time. Upon the completion of the calibration of an instrument, the 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 twelve (12) months.

### 8.3 Laboratory Surveys

1. The Radiation Safety Officer will conduct periodic laboratory surveys. This will consist of both an instrument survey (calibrated) and a wipe survey. This survey is to serve as a check and should not be used as a substitute for the surveys that are required of the investigator. The radionuclide records of the user will also usually be checked at this time.
2. Laboratory areas where only small quantities of radioactive material are used (less than 100  $\mu$  Ci) must be surveyed monthly.
3. Dispensing areas will be surveyed after dispensing is completed.
4. The weekly and monthly surveys shall consist of:
  - a) A measurement of radiation levels with a survey meter sufficiently sensitive to detect 0.1 mR/h.
  - b) A series of wipe tests to measure contamination levels. The method of performing wipe tests shall be sufficiently sensitive to detect 200 dpm.
5. A permanent record shall be kept of all survey results, including negative results.
6. Areas shall be cleaned if the contamination level exceeds 200 dpm/100cm<sup>2</sup>.

## 9.0 RULES FOR THE SAFE HANDLING OF RADIOACTIVE MATERIALS

### 9.1 Protection from External Sources

1. The external radiation hazard can be reduced by considering three factors; time, distance and shielding. These factors must be balanced against each other in every situation. For example, doubling the handling speed is equal to doubling the shielding while increasing the working distance from the source by a factor of 2 decreases the exposure by a factor of 4. Increasing the working distance from a source can be achieved through the use of remote manipulators.
2. Continuous monitoring is the best method of evaluating the hazard and thereby reducing exposure. Users of radionuclides should have on hand adequate survey instruments to keep a check on operations, and should be

thoroughly familiar with appropriate survey methods and requirements for instrument maintenance and calibration (see section 8.2). Persons issued monitoring equipment (film badges, etc.) shall wear this equipment at all times when in restricted areas. Such equipment should not be worn home.

3. Radioactive material must be stored and used in a way which prevents unauthorized access to these materials.
4. All containers for radioactive material and the areas in which they are used shall be properly labeled (see section 6.0).
5. Always transport radioactive material in shielded containers.

## 9.2 Prevention of Internal Contamination

1. Since the maximum permissible levels of radioactive contamination in the air or on environmental surfaces are often of such low levels as to be undetectable with ordinary survey instruments, extreme care must be taken to prevent such contamination. Any time that low level contamination is suspected (and any time a spill occurs) the Radiation Safety Officer should be contacted to conduct a survey and render advice.
2. Careful techniques and extreme personal cleanliness are the primary means of preventing contamination and entrance of radioactivity into the body. Therefore, the following rules should be observed in areas where unsealed sources are stored or used:
  - a) Eating, drinking, smoking and use of cosmetics are not permitted in laboratories or rooms where radioactive materials are used or stored.
  - b) Pipetting radioactive solutions by mouth is forbidden; a remote pipetting device is mandatory for such procedures.
  - c) Appropriate protective clothing must be worn. A Laboratory coat and gloves are considered minimal. Clothing should be monitored before being returned to the laundry. Suitable gloves must be worn when contamination may occur. Surgical glove techniques should be used for putting on and removing gloves to avoid contamination of inside surfaces.
  - d) Hands and clothing should be monitored before leaving the laboratory.
  - e) Wounds should be specially protected (e.g. water proof adhesive) to prevent entry of radioactive material into the body. Extreme caution should be used to avoid cuts or puncture wounds, especially when working with materials of high radiotoxicity and/or high radioactivity.
  - f) Care must be exercised to avoid skin contact with radioactive materials when using organic solvents since such solvents may make the skin more permeable.



- g) Auxiliary containers, blotters and covers (plastic-backed absorbent paper) shall be used whenever there is the possibility of a spill or contamination.
- h) The risk of spills can be reduced by use of:
  - 1. double containers
  - 2. protective covering and lids
  - 3. unbreakable containers to store radionuclides
  - 4. a "dry run" procedure without radioactive materials before employing radioactive materials
- i) If contamination is suspected, all work should be halted immediately and the Radiation Safety Officer contacted.
- j) Contaminated equipment or equipment suspected of contamination must be isolated in a designated lab or storage area and should be monitored before being removed from the laboratory. (Extraneous equipment should not be brought into the area containing radioactive material).
- k) Removable contamination must not be allowed to remain, especially on floors. This is especially important in areas where shoe covers are not routinely worn. (Removable contamination is taken to mean greater than 200 dpm as detected by a standard wipe test on a surface area of 100 cm<sup>2</sup>).
- 3. Gaseous radionuclides and solutions of volatile radionuclides shall be handled in such a manner that air concentrations in restricted and unrestricted areas do not exceed the maximum permissible concentrations given in Appendix B, Tables I and II, respectively, of 10 CFR Part 20, and are kept as low as reasonably achievable.

### 9.3 Leak Testing of Sealed Sources

- 1. Any sealed source containing byproduct material, other than hydrogen-3, with a half-life greater than thirty days, in any form other than gas, and containing more than 100 microcuries of beta and/or gamma emitting material or more than 10 microcuries of alpha emitting material, shall be tested for contamination and/or leakage prior to use.
- 2. The leak test shall be capable of detecting the presence of 0.005 microcuries of radioactive material on the test sample.
- 3. Required leak testing of sealed sources shall be performed at intervals not to exceed six months.

4. Records of leak test results shall be kept in units of microcuries.
5. If a leak test reveals the presence of 0.005 microcuries or more of removable contamination, the sealed source shall be withdrawn from use immediately. The source will then be decontaminated and repaired or disposed of in accordance with NRC and hospital regulations.
6. Leak testing of sealed sources shall be performed or supervised by the Radiation Safety Officer.

#### 9.4 Storage of Radioactive Material

1. Radioactive materials requiring a "CAUTION: RADIOACTIVE MATERIALS" label must be stored in areas under the control of the user, which shall be locked or otherwise secured against unauthorized removal of the material.
2. Radioactive materials shall be stored in a container, shielded if necessary, such that no individual in a restricted or unrestricted area is likely to exceed the maximum permissible exposures given in Section 7.2. Whenever possible, the exposure rate at one foot from the container(s) should not exceed 2.5 mR/h.
3. Containers must be properly labeled and warning signs posted where necessary.
4. Suitable precautions shall be taken so that the probability of an explosion in the storage area, which would cause the dispersion of the radioactivity, is vanishingly small.

#### 9.5 Transportation of Radioactive Materials on the Company Premises

1. Radioactive materials requiring a "CAUTION: RADIOACTIVE MATERIALS" label must be enclosed in shatter-proof carrying cases or containers (preferably metallic) before being transported through corridors.
2. Containers for the transportation of beta sources requiring a "CAUTION: RADIOACTIVE MATERIALS" label must be thicker than the maximum range of the beta rays.
3. Gamma-ray emitters shall be transported in closed containers, shielded if necessary, such that the dose-rate at the surface does not exceed 200 mrem per hour, and the dose-rate at one meter does not exceed 10 mrem/hour.

### 10.0 RADIOACTIVE WASTE DISPOSAL

#### 10.1 Storage of Radioactive Wastes

1. Each laboratory or production area should maintain a metal waste can preferably with a foot operated lid, which must display a "CAUTION: RADIOACTIVE MATERIALS" label in a prominent position. The use of a disposable liner is recommended in order to minimize contamination of the waste can. Where there is a large turnover of waste, it is

advantageous to maintain separate cans for combustible and non-combustible or reclaimable materials. Combustible waste in the laboratory should be kept at a minimum.

2. Radioactive wastes must be stored only in restricted areas where they can be secured against unauthorized removal.
3. Waste that contains short-lived radioactive material should be stored temporarily in a marked area to permit substantial decay before ultimate disposal.
4. Liquid wastes should be stored in unbreakable containers, preferably in polyethylene bottles. There must be no possibility of a chemical reaction during storage that might cause an explosion or cause the release of radioactive gases or vapors. Liquids shall be neutralized before disposition in a waste container.

#### 10.2 Liquid Wastes

1. Licensed radioactive material may be discharged into the sanitary sewerage system via a designated sink if:
  - a) The material is readily soluble or dispersible in water, and
  - b) The quantity of radioactive material released in any one day is less than ten times the quantity of such material specified in Appendix C of 10 CFR Part 20 (Appendix 2 of Radiation Safety Manual), or
  - c) The quantity of radioactive material released in any one day, diluted by the average daily quantity of sewage released into the sewer by the licensee, will result in an average radioactive concentration equal to the limits specified in Appendix B, Table I, column 2 of 10 CFR Part 20, and
  - d) The quantity of radioactive material released per month, if diluted by the average monthly quantity of water released by the licensee, will not result in an average radioactive concentration exceeding the limits specified in Appendix B, Table 1, column 2, 10 CFR Part 20, and
  - e) The gross quantity of radioactive material released into the sewerage system by the licensee does not exceed one curie per year.
2. Prior to the disposal of any liquid radioactive material to the sanitary sewerage system, approval and limits shall be obtained from the Radiation Safety Officer.
3. Short-lived liquid wastes can be stored for decay by the individual user.
4. Long-lived liquid wastes that cannot be disposed of via the sanitary sewerage system shall be transferred to the Radiation Safety Officer for disposal via a commercial waste disposal service.

## 11.0 EMERGENCY PROCEDURES

### 11.1 Minor Spills Involving No Significant Radiation Hazard to Personnel

1. Notify all persons in the room at once.
2. Confine the spill immediately.
  - a) liquid spills:
    1. Don protective gloves.
    2. Drop absorbent paper on spill.
  - b) Dry spills:
    1. Don protective gloves.
    2. Dampen area thoroughly, taking care not to spread the contamination.
3. The spread of radioactive contamination can be diminished by restricting the number and movements of persons in the spill area until the extent of shoe and clothing contamination is ascertained.
4. Notify the Radiation Safety Officer as soon as possible.
5. Decontaminate the area.
6. Monitor all persons involved in the spill and clean up; decontaminate if necessary.

### 11.2 Major Spills Involving Significant Radiation Hazard to Personnel

1. Notify all persons not involved in the spill to vacate the room at once.
2. If the spill is liquid, and the hands are protected, right the container.
3. If the spill is on the skin, flush thoroughly.
4. If the spill is on clothing, discard outer or protective clothing at once.
5. Switch off all fans and air conditioners.
6. Vacate the room.
7. The spread of radioactive contamination can be diminished by restricting the movements of potentially contaminated persons to a local zone just outside of the spill area until the extent of shoe and clothing contamination is ascertained.



8. Every person who might have been contaminated should be monitored for radioactivity, and, if contaminated, should remove his clothes and be decontaminated. If no means are available for monitoring, it should be assumed that the person is contaminated.
9. Notify the Radiation Safety Officer as soon as possible.
10. Immediately take the necessary steps to decontaminate personnel involved.
11. Decontaminate the area. (Personnel involved in the decontamination must be adequately protected). See Appendix 4.
12. Monitor all persons involved in the spill and cleanup to determine adequacy of decontamination.
13. Permit no person to resume work in the area until a survey is made and approval of the Radiation Safety Officer is secured.
14. Prepare and submit to the Radiation Safety Officer within 14 days a complete written history of the accident and subsequent activity related thereto.

11.3 Accidents Involving Radioactive Dusts, Mists, Fumes, Organic Vapors and Gases

1. Notify all other persons to vacate the room immediately.
2. Hold breath and close escape valves, switch off air conditioning devices, etc. if time permits.
3. Vacate the room.
4. Notify the Radiation Safety Officer at once.
5. Be sure that all doors giving access to the room are closed and sealed by the use of wide masking tape or adhesive tape and heavy paper. Post conspicuous warning signs or guards to prevent accidental opening of doors.
6. Report at once all known or suspected inhalations of radioactive materials.
7. Evaluate the hazard and the necessary safety devices for safe re-entry.
8. Determine the cause of contamination and rectify the condition.
9. Decontaminate the area under supervision of the Radiation Safety Officer.
10. Perform air survey of the air before permitting work to be resumed.
11. Monitor all persons suspected of contamination.

8. Every person who might have been contaminated should be monitored for radioactivity, and, if contaminated, should remove his clothes and be decontaminated. If no means are available for monitoring, it should be assumed that the person is contaminated.
9. Notify the Radiation Safety Officer as soon as possible.
10. Immediately take the necessary steps to decontaminate personnel involved.
11. Decontaminate the area. (Personnel involved in the decontamination must be adequately protected). See Appendix 4.
12. Monitor all persons involved in the spill and cleanup to determine adequacy of decontamination.
13. Permit no person to resume work in the area until a survey is made and approval of the Radiation Safety Officer is secured.
14. Prepare and submit to the Radiation Safety Officer within 14 days a complete written history of the accident and subsequent activity related thereto.

#### 11.3 Accidents Involving Radioactive Dusts, Mists, Fumes, Organic Vapors and Gases

1. Notify all other persons to vacate the room immediately.
2. Hold breath and close escape valves, switch off air conditioning devices, etc. if time permits.
3. Vacate the room.
4. Notify the Radiation Safety Officer at once.
5. Be sure that all doors giving access to the room are closed and sealed by the use of wide masking tape or adhesive tape and heavy paper. Post conspicuous warning signs or guards to prevent accidental opening of doors.
6. Report at once all known or suspected inhalations of radioactive materials.
7. Evaluate the hazard and the necessary safety devices for safe re-entry.
8. Determine the cause of contamination and rectify the condition.
9. Decontaminate the area under supervision of the Radiation Safety Officer.
10. Perform air survey of the air before permitting work to be resumed.
11. Monitor all persons suspected of contamination.

12. Prepare and submit to the Radiation Safety Officer within 14 days a complete written history of the accident and subsequent activity related thereto.

#### 11.4 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 Radiation Safety Officer as soon as possible.
3. Immediately call a physician qualified to treat radiation injuries.
4. Permit no person involved in a radiation injury to return to work without the approval of the Radiation Safety Officer and the attending physician.
5. Prepare and submit to the Radiation Safety Officer within 14 days a complete written history of the accident and the subsequent activity related thereto.

#### 11.5 Fires or Other Major Emergencies

1. Notify all other persons in the room and building at once.
2. Attempt to put out fires if radiation hazard is not immediately present.
3. Notify Safety Department.
4. Notify the radiation Safety Officer.
5. Govern fire-fighting or other emergency activities by the restrictions of the Radiation Safety Officer.
6. Following the emergency, monitor the area and determine the protective apparatus necessary for safe decontamination.
7. Decontaminate under supervision of Radiation Safety Officer.
8. Permit no person to resume work without approval of Radiation Safety Officer.
9. Prepare and submit to the Radiation Safety Officer within 14 days a complete written history of the emergency and subsequent activity related thereto.

#### 11.6 Sealed Source Rupture

1. No immediate attempt should be made to clean up the spill.

2. All windows should be closed, fans and air conditioners should be shut off, and everyone should leave the room.
3. All doors should be closed and locked.
4. The Radiation Safety Officer should be immediately notified. If necessary, outside consultants experienced in such radiation hazards will be called and their advice followed.
5. If powdered or gaseous sources are involved, the door and all other openings leading into the room should be sealed by the use of wide masking tape, or adhesive tape and heavy wrapping paper.
6. The spread of radioactive contamination can be diminished by restricting the movements of potentially contaminated persons to a local zone just outside the spill area until the extent of shoe and clothing contamination is determined.
7. Every person who might have been contaminated should be monitored for radioactivity, and, if contaminated, should remove his clothing and be decontaminated. If no means are available for monitoring, it should be assumed that the person is contaminated.
8. Prepare and submit within 14 days a complete written history of the accident and the subsequent activity related thereto.

#### 12.( PACKAGING AND TRANSPORTING RADIOACTIVE MATERIALS

For safe practices in packaging and transporting radioactive materials we operate under the general rules of the U.S. Department of Transportation; Title 49, Code of Federal Regulations, Parts 100 thru 199.

A simplified and more useable form of the regulation has been prepared by the American National Standards Institute. We have adopted this format which follows.

## RULES and REGULATIONS

TITLE 10, CHAPTER 1, CODE OF FEDERAL REGULATIONS—ENERGY

**PART  
19****NOTICES, INSTRUCTIONS, AND REPORTS TO WORKERS;  
INSPECTIONS****Sec.**

19.1 Purpose.

19.2 Scope.

19.3 Definitions.

19.4 Interpretations.

19.5 Communications.

19.6 Information collection requirements:  
OMB approval.

19.11 Posting of notices to workers.

19.12 Instructions to workers.

19.13 Notifications and reports to individuals.

19.14 Presence of representatives of licensees and workers during inspections.

19.15 Consultation with workers during inspections.

19.16 Requests by workers for inspections.

19.17 Inspections not warranted; informal review.

19.30 Violations.

19.31 Application for exemptions.

19.32 Discrimination prohibited.

Authority: Secs. 53, 83, 81, 103, 104, 161, 186, 66 Stat. 930, 933, 935, 936, 937, 940, 955, as amended, sec. 234, 83 Stat. 444, as amended (42 U.S.C. 2073, 2093, 2111, 2133, 2134, 2201, 2236, 2282); sec. 201, 66 Stat. 1242, as amended by Pub. L. 94-79, 66 Stat. 413 (42 U.S.C. 5841); Pub. L. 95-601, sec. 10, 62 Stat. 2951 (42 U.S.C. 5851).

For the purposes of sec. 223, 66 Stat. 958, as amended (42 U.S.C. 2273); §§ 19.11(a), (c), (d), and (e) and 19.12 are issued under sec. 181b, 66 Stat. 948, as amended (42 U.S.C. 2201(b)); and §§ 19.12 and 19.14(a) are issued under sec. 181c, 66 Stat. 950, as amended (42 U.S.C. 2201(c)).

**§ 19.1 Purpose.**

The regulations in this part establish requirements for notices, instructions, and reports by licensees to individuals participating in licensed activities, and options available to such individuals in connection with Commission inspections of licensees to ascertain compliance with the provisions of the Atomic Energy Act of 1954, as amended, Title II of the Energy Reorganization Act of 1974, and regulations, orders, and licenses thereunder regarding radiological working conditions.

**§ 19.2 Scope.**

The regulations in this part apply to all persons who receive, possess, use, or transfer material licensed by the Nuclear Regulatory Commission pursuant to the regulations in Parts 30 through 35, 40, 60, 61, 70 or 72 of this chapter, including persons licensed to operate a production or utilization facility pursuant to Part 50 of this chapter and persons licensed to possess power reactor spent fuel in an independent spent fuel storage installation (ISFSI) pursuant to Part 72 of this chapter.

**§ 19.3 Definitions.**

As used in this part:

(a) "Act" means the Atomic Energy Act of 1954, (66 Stat. 919) including any amendments thereto;

(b) "Commission" means the United States Nuclear Regulatory Commission;

(c) "Worker" means an individual engaged in activities licensed by the Commission and controlled by a licensee, but does not include the licensee.

(d) "License" means a license issued under the regulations in Parts 30 through 35, 40, 60, 61, 70 or 72 of this chapter, including licenses to operate a production or utilization facility pursuant to Part 50 of this chapter and licenses to possess power reactor spent fuel in an independent spent fuel storage installation (ISFSI) pursuant to Part 72 of this chapter. "Licensee" means the holder of such a license.

(e) "Restricted area" means any area access to which 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 residential building may be set apart as a restricted area.

**§ 19.4 Interpretations.**

Except as specifically authorized by the Commission in writing, no interpretation of the meaning of the regulations in this part by any officer or employee of the Commission other than a written interpretation by the General Counsel will be recognized to be binding upon the Commission.

**§ 19.5 Communications.**

Except where otherwise specified in this part, all communications and reports concerning the regulations in this part should be addressed to the Director, Office of Inspection and Enforcement, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555. Communications, reports, and applications may be delivered in person at the Commission's offices at 1717 H Street, NW., Washington, D.C.; or at 7920 Norfolk Avenue, Bethesda, Maryland.

**§ 19.6 Information collection requirements: OMB approval.**

(a) The Nuclear Regulatory Commission has submitted the information collection requirements contained in this part to the Office of Management and Budget (OMB) for approval as required by the Paperwork Reduction Act of 1980 (44 U.S.C. 3501 et seq.). OMB has approved the information collection requirements contained in this part under control

number 3150-0044.

(b) The approved information collection requirements contained in this part appear in § 19.13.

**§ 19.11 Posting of notices to workers.**

(a) Each licensee shall post current copies of the following documents: (1) The regulations in this part and in Part 20 of this chapter; (2) the license, license conditions, or documents incorporated into a license by reference, and amendments thereto; (3) the operating procedures applicable to licensed activities; (4) any notice of violation involving radiological working conditions, proposed imposition of civil penalty, or order issued pursuant to Subpart B of Part 2 of this chapter, and any response from the licensee.

(b) If posting of a document specified in paragraph (a) (1), (2) or (3) of this section is not practicable, the licensee may post a notice which describes the document and states where it may be examined.

(c) Each licensee and applicant shall post Form NRC-3, (Revision 6-82 or later) "Notice to Employees," as required by Parts 30, 40, 50, 60, 70, 72, and 150 of this chapter.

(d) Documents, notices, or forms posted pursuant to this section shall appear in a sufficient number of places to permit individuals engaged in licensed activities to observe them on the way to or from any particular licensed activity location to which the document applies, shall be conspicuous, and shall be replaced if defaced or altered.

(e) Commission documents posted pursuant to paragraph (a) (4) of this section shall be posted within 2 working days after receipt of the documents from the Commission; the licensee's response, if any, shall be posted within 2 working days after dispatch by the licensee. Such documents shall remain posted for a minimum of 5 working days or until action correcting the violation has been completed, whichever is later.

**§ 19.12 Instructions to workers.**

All individuals working in or frequenting any portion of a restricted area shall be kept informed of the storage, transfer, or use of radioactive materials or of radiation in such portions of the restricted area; shall be instructed in the health protection problems associated with exposure to such radioactive materials or radiation, in precautions or procedures to minimize exposure, and in the purposes and functions of protective devices employed; shall be instructed in, and instructed to observe, to the extent within the worker's control, the applicable provisions of Commission regulations



and licenses for the protection of personnel from exposures to radiation or radioactive materials occurring in such areas; shall be instructed of their responsibility to report promptly to the licensee any condition which may lead to or cause a violation of Commission regulations and licenses or unnecessary exposure to radiation or to radioactive material; shall be instructed in the appropriate response to warnings made in the event of any unusual occurrence or malfunction that may involve exposure to radiation or radioactive material; and shall be advised as to the radiation exposure reports which workers may request pursuant to § 19.13. The extent of these instructions shall be commensurate with potential radiological health protection problems in the restricted area.

#### § 19.13 Notifications and reports to individuals.

(a) Radiation exposure data for an individual, and the results of any measurements, analyses, and calculations of radioactive material deposited or retained in the body of an individual, shall be reported to the individual as specified in this section. The information reported shall include data and results obtained pursuant to Commission regulations, orders or license conditions, as shown in records maintained by the licensee pursuant to Commission regulations. Each notification and report shall: be in writing; include appropriate identifying data such as the name of the licensee, the name of the individual, the individual's social security number; include the individual's exposure information; and contain the following statement:

This report is furnished to you under the provisions of the Nuclear Regulatory Commission regulation 10 CFR Part 19. You should preserve this report for further reference.

(b) At the request of any worker, each licensee shall advise such worker annually of the worker's exposure to radiation or radioactive material as shown in records maintained by the licensee pursuant to § 20.401(a) and (c).

(c) At the request of a worker formerly engaged in licensed activities controlled by the licensee, each licensee shall furnish to the worker a report of the worker's exposure to radiation or radioactive material. Such report shall be furnished within 30 days from the time the request is made, or within 30 days after the exposure of the individual has been determined by the licensee, whichever is later; shall cover, within the period of time specified in the request, each calendar quarter in which the worker's activities involved exposure to radiation from radioactive materials licensed by the Commission; and shall include the dates and locations of licensed activities in which the worker participated during this period.

(d) When a licensee is required pursuant to § 20.405 or § 20.408 of this chapter to report to the Commission any exposure of an individual to radiation or radioactive material the licensee shall also provide the individual a report on his exposure data included therein. Such

report shall be transmitted at a time not later than the transmittal to the Commission.

(e) At the request of a worker who is terminating employment in a given calendar quarter with the licensee in work involving radiation dose, or of a worker who, while employed by another person, is terminating assignment to work involving radiation dose in the licensee's facility in that calendar quarter, each licensee shall provide to each such worker, or to the worker's designee, at termination, a written report regarding the radiation dose received by that worker from operations of the licensee during that specifically identified calendar quarter or fraction thereof, or provide a written estimate of that dose if the finally determined personnel monitoring results are not available at that time. Estimated doses shall be clearly indicated as such.

#### § 19.14 Presence of representatives of licensees and workers during inspections.

(a) Each licensee shall afford to the Commission at all reasonable times opportunity to inspect materials, activities, facilities, premises, and records pursuant to the regulations in this chapter.

(b) During an inspection, Commission inspectors may consult privately with workers as specified in § 19.15. The licensee or licensee's representative may accompany Commission inspectors during other phases of an inspection.

(c) If, at the time of inspection, an individual has been authorized by the workers to represent them during Commission inspections, the licensee shall notify the inspectors of such authorization and shall give the workers' representative an opportunity to accompany the inspectors during the inspection of physical working conditions.

(d) Each workers' representative shall be routinely engaged in licensed activities under control of the licensee and shall have received instructions as specified in § 19.12.

(e) Different representatives of licensees and workers may accompany the inspectors during different phases of an inspection if there is no resulting interference with the conduct of the inspection. However, only one workers' representative at a time may accompany the inspectors.

(f) With the approval of the licensee and the workers' representative an individual who is not routinely engaged in licensed activities under control of the licensee, for example, a consultant to the licensee or to the workers' representative, shall be afforded the opportunity to accompany Commission inspectors during the inspection of physical working conditions.

(g) Notwithstanding the other provisions of this section, Commission inspectors are authorized to refuse to permit accompaniment by any individual who

deliberately interferes with a fair and orderly inspection. With regard to areas containing information classified by an agency of the U.S. Government in the interest of national security, an individual who accompanies an inspector may have access to such information only if authorized to do so. With regard to any area containing proprietary information, the workers' representative for that area shall be an individual previously authorized by the licensee to enter that area.

#### § 19.15 Consultation with workers during inspections.

(a) Commission inspectors may consult privately with workers concerning matters of occupational radiation protection and other matters related to applicable provisions of Commission regulations and licenses to the extent the inspectors deem necessary for the conduct of an effective and thorough inspection.

(b) During the course of an inspection any worker may bring privately to the attention of the inspectors, either orally or in writing, any past or present condition which he has reason to believe may have contributed to or caused any violation of the act, the regulations in this chapter, or license condition, or any unnecessary exposure of an individual to radiation from licensed radioactive material under the licensee's control. Any such notice in writing shall comply with the requirements of § 19.16(a).

(c) The provisions of paragraph (b) of this section shall not be interpreted as authorization to disregard instructions pursuant to § 19.12.

#### § 19.16 Requests by workers for inspections.

(a) Any worker or representative of workers who believes that a violation of the Act, the regulations in this chapter, or license conditions exists or has occurred in license activities with regard to radiological working conditions in which the worker is engaged, may request an inspection by giving notice of the alleged violation to the Director of Inspection and Enforcement, to the Director of the appropriate Commission Regional Office, or to Commission inspectors. Any such notice shall be in writing, shall set forth the specific grounds for the notice, and shall be signed by the worker or representative of workers. A copy shall be provided the licensee by the Director of Inspection and Enforcement, Regional Office Director,

or the inspector no later than at the time of inspection except that, upon the request of the worker giving such notice, his name and the name of individuals referred to therein shall not appear in such copy or on any record published, released, or made available by the Commission, except for good cause shown.

(b) If, upon receipt of such notice, the Director of Inspection and Enforcement or Regional Office Director determines that the complaint meets the requirements set forth in paragraph (a) of this section, and that there are reasonable grounds to believe that the alleged violation exists or has occurred, he shall cause an inspection to be made as soon as practicable, to determine if such alleged violation exists or has occurred. Inspections pur-

# PART 19 • NOTICES, INSTRUCTIONS, AND REPORTS TO WORKERS; INSPECTIONS

suant to this section need not be limited to matters referred to in the complaint.

## § 19.17 Inspections not warranted; informal review.

(a) If the Director of Inspection and Enforcement or of the appropriate Regional Office determines, with respect to a complaint under § 19.16, that an inspection is not warranted because there are no reasonable grounds to believe that a violation exists or has occurred, he shall notify the complainant in writing of such determination. The complainant may obtain review of such determination by submitting a written statement of position with the Executive Director for Operations, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, who will provide the licensee with a copy of such statement by certified mail, excluding, at the request of the complainant, the name of the complainant. The licensee may submit an opposing written statement of position with the Executive Director for Operations who will provide the complainant with a copy of such statement by certified mail. Upon the request of the complainant, the Executive Director for Operations or his designee may hold an informal conference in which the complainant and the licensee may orally present their views. An informal conference may also be held at the request of the licensee, but disclosure of the identity of the complainant will be made only following receipt of written authorization from the complainant. After considering all written and oral views presented, the Executive Director for Operations shall affirm, modify, or reverse the determination of the Director of Inspection and Enforcement or of the appropriate Regional Office and furnish the complainant and the licensee a written notification of his decision and the reason therefor.

(b) If the Director of Inspection and Enforcement or of the appropriate Regional Office determines that an inspection is not warranted because the requirements of § 19.16(a) have not been met, he shall notify the complainant in writing of such determination. Such determination shall be without prejudice to the filing of a new complaint meeting the requirements of § 19.16(a).

## § 19.20 Employee protection.

Employment discrimination by a licensee or a contractor or subcontractor of a licensee against an employee for engaging in protected activities under this part or Parts 30, 40, 50, 60, 70, 72, or 150 of this chapter is prohibited.

## § 19.30 Violations.

An injunction or other court order may be obtained prohibiting any violation of any provision of the Act or Title II of the Energy Reorganization Act of 1974, or any regulation or order issued thereunder.

A court order may be obtained for the payment of a civil penalty imposed pursuant to section 234 of the Act for violation of section 53, 57, 62, 63, 81, 82, 101, 103, 104, 107, or 109 of the Act or any rule, regulation, or order issued thereunder, or any term, condition or limitation of any license issued thereunder, or for any violation for which a license may be revoked under section 186 of the Act. Any person who willfully violates any provision of the Act or any regulation or order issued thereunder may be guilty of a crime and, upon conviction, may be punished by fine or imprisonment or both, as provided by law.

## § 19.31 Application for exemptions.

The Commission may, upon application by any licensee or upon its own initiative, grant such exemptions from the requirements of the regulations in this part as it determines are authorized by law and will not result in undue hazard to life or property.

## § 19.32 Discrimination prohibited.

No person shall on the ground of sex be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any program or activity licensed by the Nuclear Regulatory Commission. This provision will be enforced through agency provisions and rules similar to those already established, with respect to racial and other discrimination, under title VI of the Civil Rights Act of 1964. This remedy is not exclusive, however, and will not prejudice or cut off any other legal remedies available to a discriminatee.

# UNITED STATES NUCLEAR REGULATORY COMMISSION

## RULES and REGULATIONS

### TITLE 10, CHAPTER 1, CODE OF FEDERAL REGULATIONS—ENERGY

# PART 20

## STANDARDS FOR PROTECTION AGAINST RADIATION

### PART 20—STANDARDS FOR PROTECTION AGAINST RADIATION

#### GENERAL PROVISIONS

- Sec.  
20.1 Purpose.  
20.2 Scope.  
20.3 Definitions.  
20.4 Units of radiation dose.  
20.5 Units of radioactivity.  
20.6 Interpretations.  
20.7 Communications.  
20.8 Information collection requirements:  
OMB approval.

#### PERMISSIBLE DOSES, LEVELS AND CONCENTRATIONS

- 20.101 Radiation dose standards for individuals in restricted areas.  
20.102 Determination of prior dose.  
20.103 Exposure of individuals to concentrations of radioactive materials in air in restricted areas.  
20.104 Exposure of minors.  
20.105 Permissible levels of radiation in unrestricted areas.  
20.106 Radioactivity in effluents to unrestricted areas.  
20.107 Medical diagnosis and therapy.  
20.108 Orders requiring furnishing of bioassay services.

#### PRECAUTIONARY PROCEDURES

- 20.201 Surveys.  
20.202 Personnel monitoring.  
20.203 Caution signs, labels, signals and controls.  
20.204 Same: exceptions.  
20.205 Procedures for picking up, receiving, and opening packages.  
20.206 Instruction of personnel.  
20.207 Storage and control of licensed materials in unrestricted areas.

#### WASTE DISPOSAL

- 20.301 General requirement.  
20.302 Method for obtaining approval of proposed disposal procedures.  
20.303 Disposal by release into sanitary sewerage systems.  
20.305 Treatment or disposal by incineration.  
20.306 Disposal of specific wastes.  
20.311 Transfer for disposal and manifests.

#### RECORDS, REPORTS, AND NOTIFICATION

- 20.401 Records of surveys, radiation monitoring, and disposal.  
20.402 Reports of theft or loss of licensed material.

#### Sec.

- 20.403 Notifications of incidents.  
20.404 [Reserved]  
20.405 Reports of overexposures and excessive levels and concentrations.  
20.406 [Reserved]  
20.407 Personnel monitoring reports.  
20.408 Reports of personnel monitoring on termination of employment or work.  
20.409 Notifications and reports to individuals.

#### EXCEPTIONS AND ADDITIONAL REQUIREMENTS

- 20.501 Applications for exemptions.  
20.502 Additional requirements.

#### ENFORCEMENT

##### 20.601 Violations.

##### APPENDIX A—[Reserved]

##### APPENDIX B—CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND

##### APPENDIX C

##### APPENDIX D—UNITED STATES NUCLEAR REGULATORY COMMISSION, INSPECTION AND ENFORCEMENT REGIONAL OFFICES

Authority: Secs. 53, 63, 65, 81, 103, 104, 161, 86 Stat. 930, 933, 935, 936, 937, 946, as amended, (42 U.S.C. 2073, 2083, 2095, 2111, 2133, 2134, 2201); sec. 201, as amended, 202, 205, Pub. L. 93-438, 88 Stat. 1242, 1244, 1246, Pub. L. 94-79, 89 Stat. 413 (42 U.S.C. 5841, 5842, 5846).

For the purposes of sec. 223, 86 Stat. 956, as amended, (42 U.S.C. 2273), §§ 20.101, 20.102, 20.103(a) (b), and (f), 20.104 (a) and (b), 20.105(b), 20.106(a), 20.201, 20.202(a), 20.206, 20.207, 20.301, 20.303, 20.304 and 20.305 are issued under sec. 181b, 86 Stat. 948, as amended, (42 U.S.C. 2201(b)); and §§ 20.102, 20.103(e), 20.401-20.407, 20.408(b) and 20.409 are issued under sec. 181c, 86 Stat. 950, as amended, (42 U.S.C. 2201(e)).

#### GENERAL PROVISIONS

##### § 20.1 Purpose.

(a) The regulations in this part establish standards for protection against radiation hazards arising out of activities under licenses issued by the Nuclear Regulatory Commission and are issued pursuant to the Atomic Energy Act of 1954, as amended, and the Energy Reorganization Act of 1974.

(b) The use of radioactive material or other sources of radiation not licensed by the Commission is not subject to the regulations in this part. However, it is the purpose of the regulations in this part to control the possession, use, and transfer of licensed material by any licensee in such a manner that the total dose to an individual (including exposures to licensed and unlicensed radioactive material and to other unlicensed sources of radiation, whether in the possession of the licensee or any other person, but not including exposures to radiation from natural background sources or medical diagnosis and therapy) does not exceed the standards of radiation protection prescribed in the regulations in this part.

(c) In accordance with recommendations of the Federal Radiation Council, approved by the President, persons engaged in activities under licenses issued by the Nuclear Regulatory Commission pursuant to the Atomic Energy Act of 1954, as amended, and the Energy Reorganization Act of 1974

should, in addition to complying with the requirements set forth in this part, make every reasonable effort to maintain radiation exposures, and releases of radioactive materials in effluents to unrestricted areas, as low as is reasonably achievable. The term "as low as is reasonably achievable" means as low as is reasonably achievable taking into account the state of technology, and the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations, and in relation to the utilization of atomic energy in the public interest.

##### § 20.2 Scope.

The regulations in this part apply to all persons who receive, possess, use, or transfer material licensed pursuant to the regulations in Parts 30 through 35, 40, 60, 61, 70, or 72 of this chapter, including persons licensed to operate a production or utilization facility pursuant to Part 50 of this chapter and persons licensed to possess power reactor spent fuel in an independent spent fuel storage installation (ISFSI) pursuant to Part 72 of this chapter.

##### § 20.3

##### § 20.3 Definitions.

(a) As used in this part:

(1) "Act" means the Atomic Energy Act of 1954 (68 Stat. 919) including any amendments thereto;

(2) "Airborne radioactive material" means any radioactive material dispersed in the air in the form of dusts, fumes, mists, vapors, or gases;

(3) "Byproduct material" means any radioactive material (except special nuclear material) yielded in or made radioactive by exposure to the radiation incident to the process of producing or utilizing special nuclear material;

(4) "Calendar quarter" means not less than 12 consecutive weeks nor more than 14 consecutive weeks. The first calendar quarter of each year shall begin in January and subsequent calendar quarters shall be such that no day is included in more than one calendar quarter or omitted from inclusion within a calendar quarter. No licensee shall change the method observed by him of determining calendar quarters except at the beginning of a calendar year.



## PART 20 • STANDARDS FOR PROTECTION AGAINST RADIATION

(5) "Commission" means the Nuclear Regulatory Commission or its duly authorized representatives;

(6) "Government agency" means any executive department, commission, independent establishment, corporation, wholly or partly owned by the United States of America which is an instrumentality of the United States, or any board, bureau, division, service, office, officer, authority, administration, or other establishment in the executive branch of the Government;

(7) "Individual" means any human being;

(8) "Licensed material" means source material, special nuclear material, or by-product material received, possessed, used, or transferred under a general or specific license issued by the Commission pursuant to the regulations in this chapter;

(9) "License" means a license issued under the regulations in Parts 30 through 35, 40, 60, 61, 70 or 72 of this chapter. "Licensee" means the holder of such license;

(10) "Occupational dose" includes exposure of an individual to radiation (i) in a restricted area; or (ii) in the course of employment in which the individual's duties involve exposure to radiation, provided, that "occupational dose" shall not be deemed to include any exposure of an individual to radiation for the purpose of medical diagnosis or medical therapy of such individual.

(11) "Person" means: (i) Any individual, corporation, partnership, firm, association, trust, estate, public or private institution, group, Government agency other than the Commission or the Department (except that the Department shall be considered a person within the meaning of the regulations in this part to the extent that its facilities and activities are subject to the licensing and related regulatory authority of the Commission pursuant to section 202 of the Energy Reorganization Act of 1974 (88 Stat. 1244)), any State, any foreign government or nation or any political subdivision of any such government or nation, or other entity; and (ii) any legal successor, representative, agent, or agency of the foregoing.

(12) "Radiation" means any or all of the following: alpha rays, beta rays, gamma rays, X-rays, neutrons, high-speed electrons, high-speed protons, and other atomic particles; but not sound or radio waves, or visible, infrared, or ultraviolet light;

(13) "Radioactive material" includes any such material whether or not subject to licensing control by the Commission;

(14) "Restricted area" means any area access to which 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 residential building may be set apart as a restricted area;

(15) "Source material" means: (i) Uranium or thorium, or any combination thereof, in any physical or chemical form; or (ii) ores which contain by weight one-twentieth of one percent (0.05%) or more of (a) uranium, (b) thorium or (c) any combination thereof. Source material does not include special nuclear material.

(16) "Special nuclear material" means: (i) Plutonium, uranium 233, uranium enriched in the isotope 233 or in the isotope 235, and any other material which the Commission, pursuant to the provisions of section 51 of the act, determines to be special nuclear material, but does not include source material; or (ii) any material artificially enriched by any of the foregoing but does not include source material;

(17) "Unrestricted area" means 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.

(18) "Department" means the Department of Energy established by the Department of Energy Organization Act (Pub. L. 95-91, 91 Stat. 565, 42 U.S.C. 5814-5816) to the extent that the Department, or its duly authorized representative, exercises functions formerly vested in the U.S. Atomic Energy Commission, its Chairman, members, officers and components and transferred to the U.S. Energy Research and Development Administration and to the Administrator thereof pursuant to sections 104 (b), (c) and (d) of the Energy Reorganization Act of 1974 (Pub. L. 93-438, 88 Stat. 1233

at 1237, 42 U.S.C. 5814) and retransferred to the Secretary of Energy pursuant to section 301(a) of the Department of Energy Organization Act (Pub. L. 95-91, 91 Stat. 565 at 577-578, 42 U.S.C. 7151).

(19) "Termination" means the end of employment with the licensee or, in the case of individuals not employed by the licensee, the end of a work assignment in the licensee's restricted areas in a given calendar quarter, without expectation or specific scheduling of reentry into the licensee's restricted areas during the remainder of that calendar quarter.

(b) Definitions of certain other words and phrases as used in this part are set forth in other sections, including:

(1) "Airborne radioactivity area" defined in § 20.203;

(2) "Radiation area" and "high radiation area" defined in § 20.202;

(3) "Personnel monitoring equipment" defined in § 20.202;

(4) "Survey" defined in § 20.201;

(5) Units of measurement of dose (rad, rem) defined in § 20.4;

(6) Units of measurement of radioactivity defined in § 20.5.

### § 20.4 Units of radiation dose.

(a) "Dose," as used in this part, is the quantity of radiation absorbed, per unit of mass, by the body or by any portion of the body. When the regulations in this part specify a dose during a period of time, the dose means the total quantity of radiation absorbed, per unit of mass, by the body or by any portion of the body during such period of time. Several different units of dose are in current use. Definitions of units as used in this part are set forth in paragraphs (b) and (c) of this section.

(b) The rad, as used in this part, is a measure of the dose of any ionizing radiation to body tissues in terms of the energy absorbed per unit mass of the tissue. One rad is the dose corresponding to the absorption of 100 ergs per gram of tissue. (One millirad (mrad)=0.001 rad.)

(c) The rem, as used in this part, is a measure of the dose of any ionizing radiation to body tissues in terms of its estimated biological effect relative to a dose of one roentgen (r) of X-rays. (One millirem (mrem)=0.001 rem.) The relation of the rem to other dose units depends upon the biological effect under consideration and upon the conditions of irradiation. For the purpose of the regulations in this part, any of the following is considered to be equivalent to a dose of one rem:

(1) A dose of 1 r due to X- or gamma radiation;

(2) A dose of 1 rad due to X-, gamma, or beta radiation;

# PART 20 • STANDARDS FOR PROTECTION AGAINST RADIATION

(3) A dose of 0.1 rad due to neutrons or high energy protons:

(4) A dose of 0.05 rad due to particles heavier than protons and with sufficient energy to reach the lens of the eye: If it is more convenient to measure the neutron flux, or equivalent, than to determine the neutron dose in rads, as provided in paragraph (c)(3) of this section, one rem of neutron radiation may, for purposes of the regulations in this part, be assumed to be equivalent to 14 million neutrons per square centimeter incident upon the body; or, if there exists sufficient information to estimate with reasonable accuracy the approximate distribution in energy of the neutrons, the incident number of neutrons per square centimeter equivalent to one rem may be estimated from the following table:

NEUTRON FLUX DOSE EQUIVALENTS

Neutron energy (Mev)	Number of neutrons per square centimeter equivalent to a dose of 1 rem (neutrons/cm <sup>2</sup> )	Average flux to deliver 100 millirem in 40 hours (neutrons/cm <sup>2</sup> sec.)
Thermal	970 × 10 <sup>4</sup>	670
0.0001	720 × 10 <sup>4</sup>	500
0.005	820 × 10 <sup>4</sup>	570
0.02	400 × 10 <sup>4</sup>	280
0.1	120 × 10 <sup>4</sup>	80
0.5	43 × 10 <sup>4</sup>	30
1.0	26 × 10 <sup>4</sup>	18
2.5	29 × 10 <sup>4</sup>	20
5.0	26 × 10 <sup>4</sup>	18
7.5	24 × 10 <sup>4</sup>	17
10	24 × 10 <sup>4</sup>	17
10 to 30	14 × 10 <sup>4</sup>	10

(d) For determining exposures to X or gamma rays up to 3 Mev, the dose limits specified in §§ 20.101 to 20.104, inclusive, may be assumed to be equivalent to the "air dose". For the purpose of this part "air dose" means that the dose is measured by a properly calibrated appropriate instrument in air at or near the body surface in the region of highest dosage rate.

## § 20.5 Units of radioactivity.

(a) Radioactivity is commonly, and for purposes of the regulations in this part shall be, measured in terms of disintegrations per unit time or in curies.

One curie =  $3.7 \times 10^{10}$  disintegrations per second (dps) =  $2.2 \times 10^{12}$  disintegrations per minute (dpm). Commonly used submultiples of the curie are the millicurie and the microcurie:

(1) One millicurie (mCi) = 0.001 curie (Ci) =  $3.7 \times 10^7$  dps.

(2) One microcurie (μCi) = 0.000001 curie =  $3.7 \times 10^4$  dps.

(b) [Deleted 40 FR 50704.]

(c) [Deleted 39 FR 23990.]

## § 20.6 Interpretations.

Except as specifically authorized by the Commission in writing, no interpretation of the meaning of the regulations in this part by any officer or employee of the Commission other than a written interpretation by the General Counsel will be recognized to be binding upon the Commission.

## § 20.7 Communications.

Except where otherwise specified in this part, all communications and reports concerning the regulations in this part should be addressed to the Executive Director for Operations, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555. Communications, reports, and applications may be delivered in person at the Commission's offices at 1717 H Street NW, Washington, D.C.; or at 7920 Norfolk Avenue, Bethesda, Maryland.

## § 20.8 Information collection requirements: OMB approval.

(a) The Nuclear Regulatory Commission has submitted the information collection requirements contained in this part to the Office of Management and Budget (OMB) for approval as required by the Paperwork Reduction Act of 1980 (44 U.S.C. 3501 et seq.). OMB has approved the information collection requirements contained in this part under control number 3150-0014.

(b) The approved information collection requirements contained in this part appear in §§ 20.102, 20.103, 20.105, 20.106, 20.203, 20.205, 20.302, 20.311, 20.401, 20.402, 20.403, 20.405, 20.407, 20.408, and 20.409.

(c) This part contains information collection requirements in addition to those approved under the control number specified in paragraph (a) of this section. These information collection requirements and the control numbers under which they are approved are as follows:

(1) In §§ 20.101 and 20.102, Form NRC-4 is approved under control number 3150-0005.

(2) In § 20.401, Form NRC-5 is approved under control number 3150-0006.

## PERMISSIBLE DOSES, LEVELS, AND CONCENTRATIONS

### § 20.101 Radiation dose standards for individuals in restricted areas.

(a) In accordance with the provisions of § 20.102(a), and except as provided in paragraph (b) of this section, no licensee shall possess, use, or transfer licensed material in such a manner as to

cause any individual in a restricted area to receive in any period of one calendar quarter from radioactive material and other sources of radiation a total occupational dose in excess of the standards specified in the following table:

REMS PER CALENDAR QUARTER

1. Whole body, head and trunk, active blood-forming organs, lens of eyes, or gonads	1 1/4
2. Hands and forearms, feet and ankles	15 1/2
3. Skin of whole body	7 1/2

(b) A licensee may permit an individual in a restricted area to receive a total occupational dose to the whole body greater than that permitted under paragraph (a) of this section, provided:

(1) During any calendar quarter the total occupational dose to the whole body shall not exceed 3 rems; and

(2) The dose to the whole body, when added to the accumulated occupational dose to the whole body, shall not exceed 5 (N-18) rems where "N" equals the individual's age in years at his last birthday; and

(3) The licensee has determined the individual's accumulated occupational dose to the whole body on Form NRC-4, or on a clear and legible record containing all the information required in that form; and has otherwise complied with the requirements of § 20.102. As used in paragraph (b), "Dose to the whole body" shall be deemed to include any dose to the whole body, gonads, active blood-forming organs, head and trunk, or lens of eye.

### § 20.102 Determination of prior dose.

(a) Each licensee shall require any individual, prior to first entry of the individual into the licensee's restricted area during each employment or work assignment under such circumstances that the individual will receive or is likely to receive in any period of one calendar quarter an occupational dose in excess of 25 percent of the applicable standards specified in § 20.101(a) and § 20.104(a), to disclose in a written, signed statement, either: (1) That the individual had no prior occupational dose during the current calendar quarter, or (2) the nature and amount of any occupational dose which the individual may have received during that specifically identified current calendar quarter from sources of radiation possessed or controlled by other persons. Each licensee shall maintain records of such statements until the Commission authorizes their disposition.

(b) Before permitting, pursuant to § 20.101(b), any individual in a restricted area to receive an occupational radiation dose in excess of the standards specified in § 20.101(a), each licensee shall:

## PART 20 • STANDARDS FOR PROTECTION AGAINST RADIATION

25 FR 10314

(1) Obtain a certificate on Form NRC-4, or on a clear and legible record containing all the information required in that form, signed by the individual showing each period of time after the individual attained the age of 18 in which the individual received an occupational dose of radiation; and

(2) Calculate on Form NRC-4 in accordance with the instructions appearing therein, or on a clear and legible record containing all the information required in that form, the previously accumulated occupational dose received by the individual and the additional dose allowed for that individual under § 20.101(b).

(c)(1) In the preparation of Form NRC-4, or a clear and legible record containing all the information required in that form, the licensee shall make a reasonable effort to obtain reports of the individual's previously accumulated occupational dose. For each period for which the licensee obtains



# PART 20 • STANDARDS FOR PROTECTION AGAINST RADIATION

such reports, the licensee shall use the dose shown in the report in preparing the form. In any case where a licensee is unable to obtain reports of the individual's occupational dose for a previous complete calendar quarter, it shall be assumed that the individual has received the occupational dose specified in whichever of the following columns apply:

Part of body	Column 1— Assumed exposure in rems for calendar quarters prior to Jan. 1, 1961	Column 2— Assumed exposure in rems for calendar quarters beginning on or after Jan. 1, 1961
Whole body, gonads, active blood-forming organs, head and trunk, lens of eye	3%	1%

(2) The licensee shall retain and preserve records used in preparing Form NRC-4 until the Commission authorizes their disposition.

If calculation of the individual's accumulated occupational dose for all periods prior to January 1, 1961 yields a result higher than the applicable accumulated dose value for the individual as of that date, as specified in paragraph (b) of § 20.101, the excess may be disregarded.

§ 20.103 Exposure of individuals to concentrations of radioactive materials in air in restricted areas.

(a)(1) No licensee shall possess, use, or transfer licensed material in such a manner as to permit any individual in a restricted area to inhale a quantity of radioactive material in any period of one calendar quarter greater than the quantity which would result from inhalation for 40 hours per week for 13 weeks at uniform concentrations of radioactive material in air specified in Appendix B, Table I, Column 1.<sup>1,2,3</sup> If

the radioactive material is of such form that intake by absorption through the skin is likely, individual exposures to radioactive material shall be controlled so that the uptake of radioactive material by any organ from either inhalation or absorption or both routes of intake<sup>4</sup> in any calendar quarter does not exceed that which would result from inhaling such radioactive material for 40 hours per week for 13 weeks at uniform concentrations specified in Appendix B, Table I, Column 1.

(2) No licensee shall possess, use, or transfer mixtures of U-234, U-235, and U-238 in soluble form in such a

manner as to permit any individual in a restricted area to inhale a quantity of such material in excess of the intake limits specified in Appendix B, Table I, Column 1 of this part. If such soluble uranium is of a form such that absorption through the skin is likely, individual exposures to such material shall be controlled so that the uptake of such material by any organ from

either inhalation or absorption or both routes of intake<sup>4</sup> does not exceed that which would result from inhaling such material at the limits specified in Appendix B, Table I, Column 1 and footnote 4 thereto.

(3) For purposes of determining compliance with the requirements of this section the licensee shall use suitable measurements of concentrations of radioactive materials in air for detecting and evaluating airborne radioactivity in restricted areas and in addition, as appropriate, shall use measurements of radioactivity in the body, measurements of radioactivity excreted from the body, or any combination of such measurements as may be necessary for timely detection and assessment of individual intakes of radioactivity by exposed individuals. It is assumed that an individual inhales radioactive material at the airborne concentration in which he is present unless he uses respiratory protective equipment pursuant to paragraph (c) of this section. When assessment of a particular individual's intake of radioactive material is necessary, intakes less than those which would result from inhalation for 2 hours in any one day or for 10 hours in any one week at uniform concentrations specified in Appendix B, Table I, Column 1 need not be included in such assessment, provided that for any assessment in excess of these amounts the entire amount is included.

(b)(1) The licensee shall, as a precautionary procedure, use process or other engineering controls, to the extent practicable, to limit concentrations of radioactive materials in air to levels below those which delimit an airborne radioactivity area as defined in § 20.203(d)(1)(ii).

(2) When it is impracticable to apply process or other engineering controls to limit concentrations of radioactive material in air below those defined in § 20.203(d)(1)(ii), other precautionary procedures, such as increased surveillance, limitation of working times, or provision of respiratory protective equipment, shall be used to maintain intake of radioactive material by any individual within any period of seven consecutive days as far below that intake of radioactive material which

would result from inhalation of such material for 40 hours at the uniform concentrations specified in Appendix B, Table I, Column 1 as is reasonably achievable. Whenever the intake of radioactive material by any individual exceeds this 40-hour control measure, the licensee shall make such evaluations and take such actions as are necessary to assure against recurrence. The licensee shall maintain records of such occurrences, evaluations, and actions taken in a clear and readily identifiable form suitable for summary review and evaluation.

(c) When respiratory protective equipment is used to limit the inhalation of airborne radioactive material pursuant to paragraph (b)(2) of this section, the licensee shall use equipment that is certified or had certification extended by the National Institute for Occupational Safety and Health/Mine Safety and Health Administration (NIOSH/MSHA). The licensee may make allowance for this use of respiratory protective equipment in estimating exposures of individuals to this material provided that:

<sup>1</sup>Since the concentration specified for tritium oxide vapor assumes equal intakes by skin absorption and inhalation, the total intake permitted is twice that which would result from inhalation alone at the concentration specified for H 3 S in Appendix B, Table I, Column 1 for 40 hours per week for 13 weeks.

<sup>2</sup>For radon-222, the limiting quantity is that inhaled in a period of one calendar year. For radioactive materials designated "Sub" in the "Isotope" column of the table, the concentration value specified is based upon exposure to the material as an external radiation source. Individual exposures to these materials may be accounted for as part of the limitation on individual dose in § 20.101. These nuclides shall be subject to the precautionary procedures required by § 20.103(b)(1).

<sup>3</sup>Multiply the concentration values specified in Appendix B, Table I, Column 1, by  $6.3 \times 10^4$  ml to obtain the quarterly quantity limit. Multiply the concentration value specified in Appendix B, Table I, Column 1, by  $2.5 \times 10^4$  ml to obtain the annual quantity limit for Rn-222.

<sup>4</sup>Significant intake by ingestion or injection is presumed to occur only as a result of circumstances such as accident, inadvertence, poor procedure, or similar special conditions. Such intakes must be evaluated and accounted for by techniques and procedures as may be appropriate to the circumstances of the occurrence. Exposures so evaluated shall be included in determining whether the limitation on individual exposures in § 20.103(a)(1) has been exceeded.

<sup>5</sup>Regulatory guidance on assessment of individual intakes of radioactive material is given in Regulatory Guide 8.9, "Acceptable Concepts, Models, Equations and Assumptions for a Bioassay Program," single copies of which are available from the Office of Standards Development, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, upon written request.

## PART 20 • STANDARDS FOR PROTECTION AGAINST RADIATION

(1) The licensee selects respiratory protective equipment that provides a protection factor greater than the multiple by which peak concentrations of airborne radioactive materials in the working area are expected to exceed the values specified in Appendix B, Table I, Column 1 of this part. The equipment so selected shall be used so that the average concentration of radioactive material in the air that is inhaled during any period of uninterrupted use in an airborne radioactivity area, on any day, by any individual using the equipment, does not exceed the values specified in Appendix B, Table I, Column 1 of this part. For the purposes of this paragraph, the concentration of radioactive material in the air that is inhaled when respirators are worn may be estimated by dividing the ambient concentration in air by the protection factor specified in Appendix A of this part. If the exposure is later found to be greater than estimated, the corrected value shall be used; if the exposure is later found to be less than estimated, the corrected value may be used.

(2) The licensee maintains and implements a respiratory protection program that includes, as a minimum: air sampling sufficient to identify the hazard, permit proper equipment selection and estimate exposures; surveys and bioassays as appropriate to evaluate actual exposures, written procedures regarding selection, fitting, and maintenance of respirators, and testing of respirators for operability immediately prior to each use; written procedures regarding supervision and training of personnel and issuance records; and determination by a physician prior to initial use of respirators, and at least every 12 months thereafter, that the individual user is physically able to use the respiratory protective equipment.

(3) A written policy statement on respirator usage shall be issued covering such things as: use of practicable engineering controls instead of respirators; routine, non-routine, and emergency use of respirators, and periods of respirator use and relief from respirator use. The licensee shall advise each respirator user that the user may leave the area at any time for relief from respirator use in the event of equipment malfunction, physical or psychological distress, procedural or communication failure, significant deterioration of operating conditions, or any other condition that might require such relief.

(4) The licensee uses equipment within limitations for type and mode of use and provides proper visual, communication, and other special capabilities (such as adequate skin protection) when needed.

(d) Unless otherwise authorized by the Commission, the licensee shall not assign protection factors in excess of

those specified in Appendix A of this part in selecting and using respiratory protective equipment. The Commission may authorize a licensee to use higher protection factors on receipt of an application (1) describing the situation for which a need exists for higher protection factors, and (2) demonstrating that the respiratory protective equipment will provide these higher protection factors under the proposed conditions of use.

(e) Where equipment of a particular type has not been tested and certified, or had certification extended, by NIOSH/MSHA, or where there is no existing schedule for test and

certification of certain equipment, the licensee shall not make allowance for this equipment without specific authorization by the Commission. An application for this authorization must include a demonstration by testing, or on the basis of reliable test information, that the material and performance characteristics of the equipment are capable of providing the proposed degree of protection under anticipated conditions of use.

(f) Only equipment that has been specifically certified or had certification extended for emergency use by NIOSH/MSHA shall be used as emergency devices.

(g) The licensee shall notify, in writing, the Director of the appropriate Nuclear Regulatory Commission Inspection and Enforcement Regional Office listed in Appendix D at least 30 days before the date that respiratory protective equipment is first used under the provisions of this section.

### § 20.104 Exposure of minors.

(a) No licensee shall possess, use, or transfer licensed material in such a manner as to cause any individual within a restricted area who is under 18 years of age, to receive in any period of one calendar quarter from radioactive material and other sources of radiation in the licensee's possession a dose in excess of 10 percent of the limits specified in the table in paragraph (a) of § 20.101.

(b) No licensee shall possess, use or transfer licensed material in such a manner as to cause any individual within a restricted area, who is under 18 years of age to be exposed to airborne radioactive material possessed by the licensee in an average concentration in excess of the limits specified in Appendix B, Table II of this part. For purposes of this paragraph, concentrations may be averaged over periods not greater than a week.

(c) The provisions of §§ 20.103(b)(2) and 20.103(c) shall apply to exposures subject to paragraph (b) of this section except that the references in §§ 20.103(b)(2) and 20.103(c) to Appendix B, Table I, Column 1 shall be deemed to be references to Appendix B, Table II, Column 1.

### § 20.105 Permissible levels of radiation in unrestricted areas.

(a) There may be included in any application for a license or for amendment of a license proposed limits upon levels of radiation in unrestricted areas resulting from the applicant's possession or use of radioactive material and other sources of radiation. Such applications should include information as to anticipated average radiation levels and anticipated occupancy times for each unrestricted area involved. The Commission will approve the proposed limits if the applicant demonstrates that the proposed limits are not likely to cause any individual to receive a dose to the whole body in any period of one calendar year in excess of 0.5 rem.

(b) Except as authorized by the Commission pursuant to paragraph (a) of this section, no licensee shall possess, use or transfer licensed material in such a manner as to create in any unrestricted area from radioactive material and other sources of radiation in his possession:

(1) Radiation levels which, if an individual were continuously present in the area, could result in his receiving a dose in excess of two millirems in any one hour, or

(2) Radiation levels which, if an individual were continuously present in the area, could result in his receiving a dose in excess of 100 millirems in any seven consecutive days.

(c) In addition to other requirements of this part, licensees engaged in uranium fuel cycle operations subject to the provisions of 40 CFR Part 190, "Environmental Radiation Protection Standards for Nuclear Power Operations," shall comply with that part.

### § 20.106 Radioactivity in effluents to unrestricted areas.

(a) A licensee shall not possess, use, or transfer licensed material so as to release to an unrestricted area radioactive material in concentrations which exceed the limits specified in Appendix B, Table II of this part, except as authorized pursuant to § 20.302 or paragraph (b) of this section. For purposes of this section concentrations may be averaged over a period not greater than one year.

## PART 20 • STANDARDS FOR PROTECTION AGAINST RADIATION

### PRECAUTIONARY PROCEDURES

#### § 20.201 Surveys.

(a) As used in the regulations in this part, "survey" means an evaluation of the radiation hazards incident to the production, use, release, disposal, or presence of radioactive materials or other sources of radiation under a specific set of conditions. When appropriate, such evaluation includes a physical survey of the location of materials and equipment, and measurements of levels of radiation or concentrations of radioactive material present.

(b) Each licensee shall make or cause to be made such surveys as (1) may be necessary for the licensee to comply with the regulations in this part, and (2) are reasonable under the circumstances to evaluate the extent of radiation hazards that may be present.

#### § 20.202 Personnel monitoring.

(a) Each licensee shall supply appropriate personnel monitoring equipment to, and shall require the use of such equipment by:

(1) Each individual who enters a restricted area under such circumstances that he receives, or is likely to receive, a dose in any calendar quarter in excess of 25 percent of the applicable value specified in paragraph (a) of § 20.101.

(2) Each individual under 18 years of age who enters a restricted area under such circumstances that he receives, or is likely to receive, a dose in any calendar quarter in excess of 5 percent of the applicable value specified in paragraph (a) of § 20.101.

(3) Each individual who enters a high radiation area.

(b) As used in this part,

(1) "Personnel monitoring equipment" means devices designed to be worn or carried by an individual for the purpose of measuring the dose received (e.g., film badges, pocket chambers, pocket dosimeters, film rings, etc.);

(2) "Radiation area" means any area, accessible to personnel, in which there exists radiation, originating in whole or in part within licensed material, at such levels that a major portion of the body could receive in any one hour a dose in excess of 5 millirem, or in any 5 consecutive days a dose in excess of 100 millirems;

(3) "High radiation area" means any area, accessible to personnel, in which there exists radiation originating in whole or in part within licensed material at such levels that a major portion of the body could receive in any one hour a dose in excess of 100 millirem.

(b) An application for a license or amendment may include proposed limits higher than those specified in paragraph (a) of this section. The

Commission will approve the proposed limits if the applicant demonstrates:

(1) That the applicant has made a reasonable effort to minimize the radioactivity contained in effluents to unrestricted areas; and

(2) That it is not likely that radioactive material discharged in the effluent would result in the exposure of an individual to concentrations of radioactive material in air or water exceeding the limits specified in Appendix B, Table II of this part.

(c) An application for higher limits pursuant to paragraph (b) of this section shall include information demonstrating that the applicant has made a reasonable effort to minimize the radioactivity discharged in effluents to unrestricted areas, and shall include, as pertinent:

(1) Information as to flow rates, total volume of effluent, peak concentration of each radionuclide in the effluent, and concentration of each radionuclide in the effluent averaged over a period of one year at the point where the effluent leaves a stack, tube, pipe, or similar conduit;

(2) A description of the properties of the effluents, including:

(i) Chemical composition;

(ii) Physical characteristics, including suspended solids content in liquid effluents, and nature of gas or aerosol for air effluents;

(iii) The hydrogen ion concentrations (pH) of liquid effluents; and

(iv) The size range of particulates in effluents released into air.

(3) A description of the anticipated human occupancy in the unrestricted area where the highest concentration of radioactive material from the effluent is expected, and, in the case of a river or stream, a description of water uses downstream from the point of release of the effluent.

(4) Information as to the highest concentration of each radionuclide in an unrestricted area, including anticipated concentrations averaged over a period of one year:

(i) In air at any point of human occupancy; or

(ii) In water at points of use downstream from the point of release of the effluent.

(5) The background concentration of radionuclides in the receiving river or stream prior to the release of liquid effluent.

(6) A description of the environmental monitoring equipment, including sensitivity of the system, and procedures and calculations to determine concentrations of radionuclides in the unrestricted area and possible recon-

centrations of radionuclides.

(7) A description of the waste treatment facilities and procedures used to reduce the concentration of radionuclides in effluents prior to their release.

(d) For the purposes of this section the concentration limits in Appendix B, Table II of this part shall apply at the boundary of the restricted area. The concentration of radioactive material discharged through a stack, pipe or similar conduit may be determined with respect to the point where the material leaves the conduit. If the conduit discharges within the restricted area, the concentration at the boundary may be determined by applying appropriate factors for dilution, dispersion, or decay between the point of discharge and the boundary.

(e) In addition to limiting concentrations in effluent streams, the Commission may limit quantities of radioactive materials released in air or water during a specified period of time if it appears that the daily intake of radioactive material from air, water, or food by a suitable sample of an exposed population group, averaged over a period not exceeding one year, would otherwise exceed the daily intake resulting from continuous exposure to air or water containing one-third the concentration of radioactive materials specified in Appendix B, Table II of this part.

(f) The provisions of paragraphs (a) through (e) of this section do not apply to disposal of radioactive material into sanitary sewerage systems, which is governed by § 20.303.

(g) In addition to other requirements of this part, licensees engaged in uranium fuel cycle operations subject to the provisions of 40 CFR Part 190, "Environmental Radiation Protection Standard for Nuclear Power Operations," shall comply with that part.

#### § 20.107 Medical diagnosis and therapy.

Nothing in the regulations in this part shall be interpreted as limiting the intentional exposure of patients to radiation for the purpose of medical diagnosis or medical therapy.

#### § 20.108 Orders requiring furnishing of bio-assay services.

Where necessary or desirable in order to aid in determining the extent of an individual's exposure to concentrations of radioactive material, the Commission may incorporate appropriate provisions in any license, directing the licensee to make available to the individual appropriate bio-assay services and to furnish a copy of the reports of such services to the Commission.



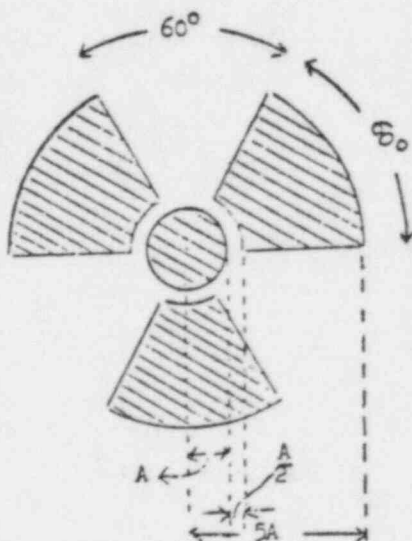
# PART 20 • STANDARDS FOR PROTECTION AGAINST RADIATION

## § 20.203 Caution signs, labels, signals and controls.

(a) *General.* (1) Except as otherwise authorized by the Commission, symbols prescribed by this section shall use the conventional radiation caution colors (magenta or purple on yellow background). The symbol prescribed by this section is the conventional three-bladed design:

### RADIATION SYMBOL

1. Cross-hatched area is to be magenta or purple.
2. Background is to be yellow.



(2) In addition to the contents of signs and labels prescribed in this section, licensees may provide on or near such signs and labels any additional information which may be appropriate in aiding individuals to minimize exposure to radiation or to radioactive material.

(b) *Radiation areas.* Each radiation area shall be conspicuously posted with a sign or signs bearing the radiation caution symbol and the words:

CAUTION<sup>1</sup>

RADIATION AREA

(c) *High radiation areas.* (1) Each high radiation area shall be conspicuously posted with a sign or signs bearing the radiation caution symbol and the words:

CAUTION<sup>1</sup>

HIGH RADIATION AREA

<sup>1</sup>Or "Danger"

(2) Each entrance or access point to a high radiation area shall be:

(i) Equipped with a control device which shall cause the level of radiation to be reduced below that at which an individual might receive a dose of 100 millirems in 1 hour upon entry into the area; or

(ii) Equipped with a control device which shall energize a conspicuous visible or audible alarm signal in such a manner that the individual entering the high radiation area and the licensee or a supervisor of the activity are made aware of the entry; or

(iii) Maintained locked except during periods when access to the area is required, with positive control over each individual entry.

(3) The controls required by paragraph (c)(2) of this section shall be established in such a way that no individual will be prevented from leaving a high radiation area.

(4) In the case of a high radiation area established for a period of 30 days or less, direct surveillance to prevent unauthorized entry may be substituted for the controls required by paragraph (c)(2) of this section.

(5) Any licensee, or applicant for a license, may apply to the Commission for approval of methods not included in paragraphs (c)(2) and (4) of this section for controlling access to high radiation areas. The Commission will approve the proposed alternatives if the licensee or applicant demonstrates that the alternative methods of control will prevent unauthorized entry into a high radiation area, and that the requirement of paragraph (c)(3) of this section is met.

(6) Each area in which there may exist radiation levels in excess of 500 rems in one hour at one meter from a sealed radioactive source<sup>2</sup> that is used to irradiate materials shall:

(i) Have each entrance or access point equipped with entry control devices which shall function automatically to prevent any individual from inadvertently entering the area when such radiation levels exist; permit deliberate entry into the area only after a control device is actuated that shall cause the radiation level within the area, from the sealed source, to be reduced below that at which it would be possible for an individual to receive a dose in excess of 100 mrem in one hour; and prevent operation of the source if the source would produce radiation levels in the area that could result in a dose to an individual in excess of 100 mrem in one hour. The entry control devices required by this paragraph (c)(6) shall be established in such a way that no individual will be prevented from leaving the area.

(ii) Be equipped with additional control devices such that upon failure of the entry control devices to function as required by paragraph (c)(6)(i) of this section the radiation level within the area, from the sealed source, shall be reduced below that at which it would be possible for an individual to receive a dose in excess of 100 mrem in one hour; and visible and audible alarm signals shall be generated to make an individual attempting to enter the area aware of the hazard and the licensee or at least one other individual, who is familiar with the activity and prepared to render or summon assistance, aware of such failure of the entry control devices.

(iii) Be equipped with control devices such that upon failure or removal of physical radiation barriers other than the source's shielded storage container the radiation level from the source shall be reduced below that at which it would be possible for an individual to receive a dose in excess of 100 mrem in one hour; and visible and audible alarm signals shall be generated to make potentially affected individuals aware of the hazard and the licensee or at least one other individual, who is familiar with the activity and prepared to render or summon assistance, aware of the failure or removal of the physical barrier. When the shield for the stored source is a liquid, means shall be provided to monitor the integrity of the shield and to signal, automatically, loss of adequate shielding. Physical radiation barriers that com-

<sup>1</sup>This paragraph (c)(6) does not apply to radioactive sources that are used in teletherapy, in radiography, or in completely self-shielded irradiators in which the source is both stored and operated within the same shielding radiation barrier and, in the designed configuration of the irradiator, is always physically inaccessible to any individual and cannot create high levels of radiation in an area that is accessible to any individual. This paragraph (c)(6) also does not apply to sources from which the radiation is incidental to some other use nor to nuclear reactor generated radiation other than radiation from byproduct, source, or special nuclear materials that are used in sealed sources in non-self-shielded irradiators.

<sup>2</sup>These requirements apply after Mar. 14, 1978. Each person licensed to conduct activities to which this paragraph (c)(6) applies and who is not in compliance with the provisions of this paragraph on Mar. 14, 1978, shall file with the Director, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, on or before June 14, 1978, information describing in detail the actions taken or to be taken to achieve compliance with this paragraph by Dec. 14, 1978, and may continue activities in conformance with present license conditions and the provisions of the previously effective § 20.2034 until such compliance is achieved. For such persons compliance must be achieved not later than Dec. 14, 1978.

## PART 20 • STANDARDS FOR PROTECTION AGAINST RADIATION

prise permanent structural components, such as walls, that have no credible probability of failure or removal in ordinary circumstances need not meet the requirements of this paragraph (c)(6)(iii).

(iv) Be equipped with devices that will automatically generate visible and audible alarm signals to alert personnel in the area before the source can be put into operation and in sufficient time for any individual in the area to operate a clearly identified control device which shall be installed in the area and which can prevent the source from being put into operation.

(v) Be controlled by use of such administrative procedure and such devices as are necessary to assure that the area is cleared of personnel prior to each use of the source preceding which use it might have been possible for an individual to have entered the area.

(vi) Be checked by a physical radiation measurement to assure that prior to the first individual's entry into the area after any use of the source, the radiation level from the source in the area is below that at which it would be possible for an individual to receive a dose in excess of 100 mrem in one hour.

(vii) Have entry control devices required in paragraph (c)(6)(i) of this section which have been tested for proper functioning prior to initial operation with such source of radiation on any day that operations are not interruptedly continued from the previous day or before resuming operations after any unintended interruption, and for which records are kept of the dates, times, and results of such tests of function. No operations other than those necessary to place the source in safe condition or to effect repairs on controls shall be conducted with such source unless control devices are functioning properly. The licensee shall submit an acceptable schedule for more complete periodic tests of the entry control and warning systems to be established and adhered to as a condition of the license.

(viii) Have those entry and exit portals that are used in transporting materials to and from the irradiation area, and that are not intended for use by individuals, controlled by such devices and administrative procedures as are necessary to physically protect and warn against inadvertent entry by any individual through such portals. Exit portals for processed materials shall be equipped to detect and signal the presence of loose radiation sources that are carried toward such an exit and to automatically prevent such loose sources from being carried out of the area.

(7) Licensees with, or applicants for, licenses for radiation sources that are within the purview of paragraph (c)(6) of this section, and that must be used in a variety of positions or in peculiar locations, such as open fields or forests, that make it impracticable to comply with certain requirements of paragraph (c)(6) of this section, such as those for the automatic control of radiation levels, may apply to the Director, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, for approval, prior to use of safety measures that are alternative to those specified in paragraph (c)(6) of this section, and that will provide at least an equivalent degree of personnel protection in the use of such sources. At least one of the alternative measures must include an entry-preventing interlock control based on a physical measurement of radiation that assures the absence of high radiation levels before an individual can gain access to an area where such sources are used.

(d) *Airborne radioactivity areas.* (1) As used in the regulations in this part "airborne radioactivity area" means (i) any room, enclosure, or operating area in which airborne radioactive materials composed wholly or partly of licensed material, exist in concentrations in excess of the amounts specified in Appendix B, Table I, Column 1 of this part; or (ii) any room, enclosure, or operating area in which airborne radioactive material composed wholly or partly of licensed material exists in concentrations which, averaged over the number of hours in any week during which individuals are in the area, exceed 25 percent of the amounts specified in Appendix B, Table I, Column 1 of this part.

(2) Each airborne radioactivity area shall be conspicuously posted with a sign or signs bearing the radiation caution symbol and the words:

"CAUTION"

### AIRBORNE RADIOACTIVITY AREA

(e) *Additional requirements.* (1) Each area or room in which licensed material is used or stored and which contains any radioactive material (other than natural uranium or thorium) in an amount exceeding 10 times the quantity of such material specified in Appendix C of this part shall be conspicuously posted with a sign or signs bearing the radiation caution symbol and the words:

"Or "Danger".

As appropriate, the information will include radiation levels, kinds of material, estimate of activity, date for which activity is estimated, mass enrichment, etc.

"CAUTION"

### RADIOACTIVE MATERIAL(S)

(2) Each area or room in which natural uranium or thorium is used or stored in any amount exceeding one hundred times the quantity specified in Appendix C of this part shall be conspicuously posted with a sign or signs bearing the radiation caution symbol and the words:

"CAUTION"

### RADIOACTIVE MATERIAL(S)

(f) *Containers.* (1) Except as provided in paragraph (f)(3) of this section, each container of licensed material shall bear a durable, clearly visible label identifying the radioactive contents.

(2) A label required pursuant to paragraph (f)(1) of this section shall bear the radiation caution symbol and the words "CAUTION, RADIOACTIVE MATERIAL" or "DANGER, RADIOACTIVE MATERIAL". It shall also provide sufficient information to permit individuals handling or using the containers, or working in the vicinity thereof, to take precautions to avoid or minimize exposures.

(3) Notwithstanding the provisions of paragraph (f)(1) of this section labeling is not required:

(i) For containers that do not contain licensed materials in quantities greater than the applicable quantities listed in Appendix C of this part.

(ii) For containers containing only natural uranium or thorium in quantities no greater than 10 times the applicable quantities listed in Appendix C of this part.

(iii) For containers that do not contain licensed materials in concentrations greater than the applicable concentrations listed in Appendix B, Table I, Column 2, of this part.

(iv) For containers when they are attended by an individual who takes the precautions necessary to prevent the exposure of any individual to radiation

or radioactive materials in excess of the limits established by the regulations in this part.

(v) For containers when they are in transport and packaged and labeled in accordance with regulations of the Department of Transportation.

(vi) For containers which are accessible only to individuals authorized to handle or use them, or to work in the vicinity thereof, provided that the contents are identified to such individuals by a readily available written record.

(vii) For manufacturing or process equipment, such as nuclear reactors, reactor components, piping, and tanks.



# PART 20 • STANDARDS FOR PROTECTION AGAINST RADIATION

(4) Each licensee shall, prior to disposal of an empty uncontaminated container to unrestricted areas, remove or deface the radioactive material label or otherwise clearly indicate that the container no longer contains radioactive materials.

## § 20.204 Same: exceptions.

Notwithstanding the provisions of § 20.203,

(a) A room or area is not required to be posted with a caution sign because of the presence of a sealed source provided the radiation level twelve inches from the surface of the source container or housing does not exceed five millirem per hour.

(b) Rooms or other areas in hospitals are not required to be posted with caution signs, and control of entrance or access thereto pursuant to § 20.203(c) is not required, because of the presence of patients containing by-product material provided that there are personnel in attendance who will take the precautions necessary to prevent the exposure of any individual to radiation or radioactive material in excess of the limits established in the regulations in this part.

(c) Caution signs are not required to be posted at areas or rooms containing radioactive materials for periods of less than eight hours provided that (1) the materials are constantly attended during such periods by an individual who shall take the precautions necessary to prevent the exposure of any individual to radiation or radioactive materials in excess of the limits established in the regulations in this part and; (2) such area or room is subject to the licensee's control.

(d) A room or other area is not required to be posted with a caution sign, and control is not required for each entrance or access point to a room or other area which is a high radiation area solely because of the presence of radioactive materials prepared for transport and packaged and labeled in accordance with regulations of the Department of Transportation.

\* For example, containers in locations such as water-filled canals, storage vaults, or hot cells.

## § 20.205 Procedures for picking up, receiving, and opening packages.

(a)(1) Each licensee who expects to receive a package containing quantities of radioactive material in excess of the Type A quantities specified in paragraph (b) of this section shall:

(i) If the package is to be delivered to the licensee's facility by the carrier, make arrangements to receive the package when it is offered for delivery by the carrier; or

(ii) If the package is to be picked up by the licensee at the carrier's terminal, make arrangements to receive notification from the carrier of the arrival of the package, at the time of arrival.

(2) Each licensee who picks up a package of radioactive material from a carrier's terminal shall pick up the package expeditiously upon receipt of notification from the carrier of its arrival.

(b)(1) Each licensee, upon receipt of a package of radioactive material, shall monitor the external surfaces of the package for radioactive contamination caused by leakage of the radioactive contents, except:

(i) Packages containing no more than the exempt quantity specified in the table in this paragraph;

(ii) Packages containing no more than 10 millicuries of radioactive material consisting solely of tritium, carbon-14, sulfur-35, or iodine-125;

(iii) Packages containing only radioactive material as gases or in special form;

(iv) Packages containing only radioactive material in other than liquid form (including Mo-99/Tc-99m generators) and not exceeding the Type A quantity limit specified in the table in this paragraph; and

(v) Packages containing only radionuclides with half-lives of less than 30 days and a total quantity of no more than 100 millicuries.

The monitoring shall be performed as soon as practicable after receipt, but no later than three hours after the package is received at the licensee's facility if received during the licensee's normal working hours, or eighteen hours if received after normal working hours.

(2) If removable radioactive contamination in excess of 0.01 microcuries (22,000 disintegrations per minute) per 100 square centimeters of package surface is found on the external surfaces of the package, the licensee shall immediately notify the final delivering carrier and, by telephone and telegraph, mailgram or facsimile, the appropriate Nuclear Regulatory Commission Inspection and Enforcement Regional Office shown in Appendix D of this part.

TABLE OF EXEMPT AND TYPE A QUANTITIES

Transport group <sup>1</sup>	Exempt quantity limit (in millicuries)	Type A quantity limit (in curies)
I	0.1	0.001
II	0.1	0.050
III	1	3
IV	1	20
V	1	20
VI	1	1000
VII	25,000	1000
Special Form	1	20

<sup>1</sup>The definitions of "transport group" and "special form" are specified in § 71.4 of this chapter.

➤ [Footnote 1 removed 49 FR 19623]

(c)(1) Each licensee, upon receipt of a package containing quantities of radioactive material in excess of the Type A quantities specified in paragraph (b) of this section, other than those transported by exclusive use vehicle, shall monitor the radiation levels external to the package. The package shall be monitored as soon as practicable after receipt, but no later than three hours after the package is received at the licensee's facility if received during the licensee's normal working hours, or 18 hours if received after normal working hours.

(2) If radiation levels are found on the external surface of the package in excess of 200 millirem per hour, or at three feet from the external surface of the package in excess of 10 millirem per hour,

the licensee shall immediately notify by telephone and telegraph mailgram, or facsimile, the director of the appropriate NRC Regional Office listed in Appendix D, and the final delivering carrier.

(d) Each licensee shall establish and maintain procedures for safely opening packages in which licensed material is received, and shall assure that such procedures are followed and that due consideration is given to special instructions for the type of package being opened.

## § 20.206 Instruction of personnel.

Instructions required for individuals working in or frequenting any portion of a restricted area are specified in § 19.12 of this chapter.

## § 20.207 Storage and control of licensed materials in unrestricted areas.

(a) Licensed materials stored in an unrestricted area shall be secured from unauthorized removal from the place of storage.

(b) Licensed materials in an unrestricted area and not in storage shall be

## PART 20 • STANDARDS FOR PROTECTION AGAINST RADIATION

tended under the constant surveillance and immediate control of the licensee.

### WASTE DISPOSAL

#### § 20.301 General requirement.

No licensee shall dispose of licensed material except:

(a) By transfer to an authorized recipient as provided in the regulations in Parts 30, 40, 60, 61, 70 or 72 of this chapter, whichever may be applicable; or

(b) As authorized under § 20.302 or Part 61 of this chapter; or

(c) As provided in § 20.303, applicable to the disposal of licensed material by release into sanitary sewerage systems, or in § 20.306 for disposal of specific wastes, or in § 20.106 (Radioactivity in effluents to unrestricted areas).

#### § 20.302 Method for obtaining approval of proposed disposal procedures.

(a) Any licensee or applicant for a license may apply to the Commission for approval of proposed procedures to dispose of licensed material in a manner not otherwise authorized in the regulations in this chapter. Each application should include a description of the licensed material and any other radioactive material involved, including the quantities and kinds of such material and the levels of radioactivity involved, and the proposed manner and conditions of disposal. The application should also include an analysis and evaluation of pertinent information as to the nature of the environment, including topographical, geological, meteorological, and hydrological characteristics; usage of ground and surface waters in the general area; the nature and location of other potentially affected facilities; and procedures to be observed to minimize the risk of unexpected or hazardous exposures.

(b) The Commission will not approve any application for a license for disposal of licensed material at sea unless the applicant shows that sea disposal offers less harm to man or the environment than other practical alternative methods of disposal.

#### § 20.303 Disposal by release into sanitary sewerage systems.

No licensee shall discharge licensed material into a sanitary sewerage system unless:

(a) It is readily soluble or dispersible in water; and

(b) The quantity of any licensed or other radioactive material released into the system by the licensee in any one day does not exceed the larger of paragraphs (b)(1) or (2) of this section.

(1) The quantity which, if diluted by the average daily quantity of sewage released into the sewer by the licensee, will result in an average concentration equal to the limits specified in Appendix B, Table I, Column 2 of this part; or

(2) Ten times the quantity of such material specified in Appendix C of this part; and

(c) The quantity of any licensed or other radioactive material released in any one month, if diluted by the average monthly quantity of water released by the licensee, will not result in an average concentration exceeding the limits specified in Appendix B, Table I, Column 2 of this part; and

(d) The gross quantity of licensed and other radioactive material, excluding hydrogen-3 and carbon-14, released into the sewerage system by the licensee does not exceed one curie per year. The quantities of hydrogen-3 and carbon-14 released into the sanitary sewerage system may not exceed 5 curies per year for hydrogen-3 and 1 curie per year for carbon-14. Excreta from individuals undergoing medical diagnosis or therapy with radioactive material shall be exempt from any limitations contained in this section.

#### § 20.305 Treatment or disposal by incineration.

No licensee shall treat or dispose of licensed material by incineration, except for materials listed under § 20.306 or as specifically approved by the Commission pursuant to §§ 20.106(b) and 20.302.

#### § 20.306 Disposal of specific wastes.

Any licensee may dispose of the following licensed material without regard to its radioactivity:

(a) 0.05 microcuries or less of hydrogen-3 or carbon-14, per gram of medium, used for liquid scintillation counting; and

(b) 0.05 microcuries or less of hydrogen-3 or carbon-14, per gram of animal tissue averaged over the weight of the entire animal; provided however, tissue may not be disposed of under this section in a manner that would permit its use either as food for humans or as animal feed.

(c) Nothing in this section, however, relieves the licensee of maintaining records showing the receipt, transfer and disposal of such byproduct material as specified in § 30.51 of this chapter; and

(d) Nothing in this section relieves the licensee from complying with other applicable Federal, State and local regulations governing any other toxic or hazardous property of these materials.

#### § 20.311 Transfer for disposal and manifests.

(a) Purpose. The requirements of this section are designed to control transfers of radioactive waste intended for disposal at a land disposal facility and establish a manifest tracking system and supplement existing requirements concerning transfers and recordkeeping for such wastes. The reporting and recordkeeping requirements contained in this section have been approved by the Office of Management and Budget; OMB approval No. 3150-0014.

(b) Each shipment of radioactive waste to a licensed land disposal facility must be accompanied by a shipment manifest that contains the name, address, and telephone number of the person generating the waste. The manifest shall also include the name, address, and telephone number or the name and EPA hazardous waste identification number of the person transporting the waste to the land disposal facility. The manifest must also indicate as completely as practicable: a physical description of the waste; the volume; radionuclide identity and quantity; the total radioactivity; and the principal chemical form. The solidification agent must be specified. Waste containing more than 0.1% chelating agents by weight must be identified and the weight percentage of the chelating agent estimated. Wastes classified as Class A, Class B, or Class C in § 61.55 of this chapter must be clearly identified as such in the manifest. The total quantity of the radionuclides H-3, C-14, Tc-99 and I-129 must be shown. The manifest required by this paragraph may be shipping papers used to meet Department of Transportation or

## PART 20 • STANDARDS FOR PROTECTION AGAINST RADIATION

Environmental Protection Agency regulations or requirements of the receiver, provided all the required information is included. Copies of manifests required by this section may be legible carbon copies or legible photocopies.

(c) Each manifest must include a certification by the waste generator that the transported materials are properly classified, described, packaged, marked, and labeled and are in proper condition for transportation according to the applicable regulations of the Department of Transportation and the Commission. An authorized representative of the waste generator shall sign and date the manifest.

(d) Any generating licensee who transfers radioactive waste to a land disposal facility or a licensed waste collector shall comply with the requirements in paragraphs (d)(1) through (8) of this section. Any generating licensee who transfers waste to a licensed waste processor who treats or repackages waste shall comply with the requirements of paragraphs (d)(4) through (8) of this section. A licensee shall:

(1) Prepare all wastes so that the waste is classified according to § 61.55 and meets the waste characteristics requirements in § 61.56 of this chapter;

(2) Label each package of waste to identify whether it is Class A waste, Class B waste, or Class C waste, in accordance with § 61.55 of this chapter;

(3) Conduct a quality control program to assure compliance with §§ 61.55 and 61.56 of this chapter; the program must include management evaluation of audits;

(4) Prepare shipping manifests to meet the requirements of §§ 20.311 (b) and (c) of this part;

(5) Forward a copy of the manifest to the intended recipient, at the time of shipment; or, deliver to a collector at the time the waste is collected, obtaining acknowledgement of receipt in the form of a signed copy of the manifest or equivalent documentation from the collector;

(6) Include one copy of the manifest with the shipment;

(7) Retain a copy of the manifest and documentation of acknowledgement of receipt as the record of transfer of licensed material as required by Parts 30, 40, and 70 of this chapter; and,

(8) For any shipments or any part of a shipment for which acknowledgement of receipt has not been received within the times set forth in this section, conduct an investigation in accordance with paragraph (h) of this section.

(e) Any waste collector licensee who handles only prepackaged waste shall:

(1) Acknowledge receipt of the waste from the generator within one week of receipt by returning a signed copy of the manifest or equivalent documentation;

(2) Prepare a new manifest to reflect consolidated shipments; the new manifest shall serve as a listing or index for the detailed generator manifests. Copies of the generator manifests shall be a part of the new manifest. The waste collector may prepare a new manifest without attaching the generator manifests, provided the new manifest contains for each package the information specified in paragraph (b) of this section. The collector licensee shall certify that nothing has been done to the waste which would invalidate the generator's certification;

(3) Forward a copy of the new manifest to the land disposal facility operator at the time of shipment;

(4) Include the new manifest with the shipment to the disposal site;

(5) Retain a copy of the manifest and documentation of acknowledgement of receipt as the record of transfer of licensed material as required by Parts 30, 40, and 70 of this chapter, and retain information from generator manifests until disposition is authorized by the Commission; and,

(6) For any shipments or any part of a shipment for which acknowledgement of receipt is not received within the times set forth in this section, conduct an investigation in accordance with paragraph (h) of this section.

(f) Any licensed waste processor who treats or repackages wastes shall:

(1) Acknowledge receipt of the waste from the generator within one week of receipt by returning a signed copy of the manifest or equivalent documentation;

(2) Prepare a new manifest that meets the requirements of paragraphs (b) and (c) of this section. Preparation of the new manifest reflects that the processor is responsible for the waste;

(3) Prepare all wastes so that the waste is classified according to § 61.55 and meets the waste characteristics requirements in § 61.56 of this chapter;

(4) Label each package of waste to identify whether it is Class A waste, Class B waste, or Class C waste, in accordance with §§ 61.55 and 61.57 of this chapter;

(5) Conduct a quality control program to assure compliance with §§ 61.55 and 61.56 of this chapter. The program shall include management evaluation of audits;

(6) Forward a copy of the new manifest to the disposal site operator or waste collector at the time of shipment, or deliver to a collector at the time the waste is collected, obtaining acknowledgement of receipt in the form of a signed copy of the manifest or

equivalent documentation by the collector;

(7) Include the new manifest with the shipment;

(8) Retain copies of original manifests and new manifests and documentation of acknowledgement of receipt as the record of transfer of licensed material required by Parts 30, 40, and 70 of this chapter; and

(9) For any shipment or part of a shipment for which acknowledgement is not received within the times set forth in this section, conduct an investigation in accordance with paragraph (h) of this section.

(g) The land disposal facility operator shall:

(1) Acknowledge receipt of the waste within one week of receipt by returning a signed copy of the manifest or equivalent documentation to the shipper. The shipper to be notified is the licensee who last possessed the waste and transferred the waste to the operator. The returned copy of the manifest or equivalent documentation shall indicate any discrepancies between materials listed on the manifest and materials received;

(2) Maintain copies of all completed manifests or equivalent documentation until the Commission authorizes their disposition; and

(3) Notify the shipper (i.e., the generator, the collector, or processor) and the Director of the nearest Commission Regional Office listed in Appendix D of this part when any shipment or part of a shipment has not arrived within 60 days after the advance manifest was received.

(h) Any shipment or part of a shipment for which acknowledgement is not received within the times set forth in this section, must:

(1) Be investigated by the shipper if the shipper has not received notification of receipt within 20 days after transfer; and

(2) Be traced and reported. The investigation shall include tracing the shipment and filing a report with the nearest Commission Regional Office listed in Appendix D of this part. Each licensee who conducts a trace investigation shall file a written report with the nearest Commission's Regional office within 2 weeks of completion of the investigation.



## PART 20 • STANDARDS FOR PROTECTION AGAINST RADIATION

§ 20.401 Records of surveys, radiation monitoring, and disposal.

(a) Each licensee shall maintain records showing the radiation exposures of all individuals for whom personnel monitoring is required under § 20.202 of the regulations in this part. Such records shall be kept on Form NRC-5, in accordance with the instructions contained in that form or on clear and legible records containing all the information required by Form NRC-5. The doses entered on the forms or records shall be for periods of time not exceeding one calendar quarter.

(b) Each licensee shall maintain records in the same units used in this part, showing the results of surveys required by § 20.201(b), monitoring required by §§ 20.205(b) and 20.205(c), and disposals made under §§ 20.302, 20.303, removed § 20.304, and Part 61 of this chapter.

(c)(1) Records of individual exposure to radiation and to radioactive material which must be maintained pursuant to the provisions of paragraph (a) of this section and records of bioassays, including results of whole body counting examinations, made pursuant to § 20.108, shall be preserved until the Commission authorizes disposition.

(2) Records of the results of surveys and monitoring which must be maintained pursuant to paragraph (b) of this section shall be preserved for two years after completion of the survey except that the following records shall be maintained until the Commission authorizes their disposition: (i) Records of the results of surveys to determine compliance with § 20.103(a); (ii) in the absence of personnel monitoring data, records of the results of surveys to determine external radiation dose; and (iii) records of the results of surveys used to evaluate the release of radioactive effluents to the environment.

(3) Records of disposal of licensed materials made pursuant to §§ 20.302, 20.303, removed § 20.304, and Part 61 of this chapter are to be maintained until the Commission authorizes their disposition.

(4) Records which must be maintained pursuant to this part may be the original or a reproduced copy or microform if such reproduced copy or microform is duly authenticated by authorized personnel and the microform is capable of producing a clear and legible copy after storage for the period specified by Commission regulations.

(5) If there is a conflict between the Commission's regulations in this part, license condition, or technical specification, or other written Commission approval or authorization pertaining to the retention period for the same type of record, the retention period specified in the regulations in this part for such records shall apply unless the Commission pursuant to § 20.501, has granted a specific exemption from the record retention requirements specified in the regulations in this part.

#### § 20.402 Reports of theft or loss of licensed material.

(a)(1) Each licensee shall report to the Commission, by telephone, immediately after it determines that a loss or theft of licensed material has occurred in such quantities and under such circumstances that it appears to the licensee that a substantial hazard may result to persons in unrestricted areas.

(2) Reports must be made as follows:

(i) Licensees having an installed Emergency Notification System shall make the reports to the NRC Operations Center in accordance with § 50.72 of this chapter.

(ii) All other licensees shall make reports to the Administrator of the appropriate NRC Regional Office listed in Appendix D of this part.

(b) Each licensee who makes a report under paragraph (a) of this section shall, within 30 days after learning of the loss or theft, make a report in writing to the U.S. Nuclear Regulatory Commission, Document Control Desk, Washington, D.C. 20555, with a copy to the appropriate NRC Regional Office listed in Appendix D of this part. The report shall include the following information:

(1) A description of the licensed material involved, including kind, quantity, chemical, and physical form;

(2) A description of the circumstances under which the loss or theft occurred;

(3) A statement of disposition or probable disposition of the licensed material involved;

(4) Radiation exposures to individuals,

circumstances under which the exposures occurred, and the extent of possible hazard to persons in unrestricted areas;

(5) Actions which have been taken, or will be taken, to recover the material; and

(6) Procedures or measures which have been or will be adopted to prevent a recurrence of the loss or theft of licensed material.

(c) Subsequent to filing the written report the licensee shall also report any substantive additional information on the loss or theft which becomes available to the licensee, within 30 days after he learns of such information.

(d) Any report filed with the Commission pursuant to this section shall be so prepared that names of individuals who may have received exposure to radiation are stated in a separate part of the report.

(e) For holders of an operating license for a nuclear power plant, the events included in paragraph (b) of this section must be reported in accordance with the procedures described in § 50.73 (b), (c), (d), (e), and (g) of this chapter and must include the information required in paragraph (b) of this section. Events reported in accordance with § 50.73 of this chapter need not be reported by a duplicate report under paragraph (b) of this section.

#### § 20.403 Notifications of incidents.

(a) *Immediate notification.* Each licensee shall immediately report any events involving byproduct, source, or special nuclear material possessed by the licensee that may have caused or threatens to cause:

(1) Exposure of the whole body of any individual to 25 rems or more of radiation; exposure of the skin of the whole body of any individual of 150 rems or more of radiation; or exposure of the feet, ankles, hands or forearms of any individual to 375 rems or more of radiation; or

(2) The release of radioactive material in concentrations which, if averaged over a period of 24 hours, would exceed 5,000 times the limits specified for such materials in Appendix B, Table II of this part; or

(3) A loss of one working week or more of the operation of any facilities affected; or

(4) Damage to property in excess of \$200,000.

(b) *Twenty-four hour notification.* Each licensee shall within 24 hours of discovery of the event, report any event involving licensed material possessed by the licensee that may have caused or threatens to cause:

(1) Exposure of the whole body of any individual to 5 rems or more of radiation; exposure of the skin of the whole body of any individual to 30 rems or more of radiation; or exposure of the feet, ankles, hands, or forearms to 75 rems or more of radiation; or

(2) The release of radioactive material in concentrations which, if averaged over a period of 24 hours, would exceed 500 times the limits specified for such materials in Appendix B, Table II of this part; or

(3) A loss of one day or more of the operation of any facilities affected; or

(4) Damage to property in excess of \$2,000.

(c) Any report filed with the Commission pursuant to this section shall be prepared so that names of individuals who have received exposure to radiation will be stated in a separate part of the report.

(d) Reports made by licensees in response to the requirements of this section must be made as follows:

(1) Licensees that have an installed Emergency Notification System shall make the reports required by paragraphs (a) and (b) of this section to the NRC Operations Center in accordance with § 50.72 of this chapter.

(2) All other licensees shall make the reports required by paragraphs (a) and (b) of this section by telephone and by telegram, mailgram, or facsimile to the Administrator of the appropriate NRC Regional Office listed in Appendix D of this part.

#### § 20.404 [Reserved]

#### § 20.405 Reports of overexposures and excessive levels and concentrations.

(a)(1) In addition to any notification required by § 20.403 of this part, each licensee shall make a report in writing concerning any one of the following types of incidents within 30 days of its occurrence:

(i) Each exposure of an individual to radiation in excess of the applicable limits in §§ 20.101 or 20.104(a) of this part, or the license;

(ii) Each exposure of an individual to radioactive material in excess of the applicable limits in §§ 20.103(a)(1), 20.103(a)(2), or 20.104(b) of this part, or in the license;



# PART 20 • STANDARDS FOR PROTECTION AGAINST RADIATION

(iii) Levels of radiation or concentrations of radioactive material in a restricted area in excess of any other applicable limit in the license;

(iv) Any incident for which notification is required by § 20.403 of this part; or

(v) Levels of radiation or concentrations of radioactive material (whether or not involving excessive exposure of any individual) in an unrestricted area in excess of ten times any applicable limit set forth in this part or in the license.

(2) Each report required under paragraph (a)(1) of this section must describe the extent of exposure of individuals to radiation or to radioactive material, including:

(i) Estimates of each individual's exposure as required by paragraph (b) of this section;

(ii) Levels of radiation and concentrations of radioactive material involved;

(iii) The cause of the exposure, levels or concentrations; and

(iv) Corrective steps taken or planned to prevent a recurrence.

(b) Any report filed with the Commission pursuant to paragraph (a) of this section shall include for each individual exposed the name, social security number, and date of birth, and an estimate of the individual's exposure. The report shall be prepared so that this information is stated in a separate part of the report.

(c)(1) In addition to any notification required by § 20.403 of this part, each licensee shall make a report in writing of levels of radiation or releases of radioactive material in excess of limits specified by 40 CFR Part 190, "Environmental Radiation Protection Standards for Nuclear Power Operations," or in excess of license conditions related to compliance with 40 CFR Part 190.

(2) Each report submitted under paragraph (c)(1) of this section must describe:

(i) The extent of exposure of individuals to radiation or to radioactive material;

(ii) Levels of radiation and concentrations of radioactive material involved;

(iii) The cause of the exposure, levels, or concentrations; and

(iv) Corrective steps taken or planned to assure against a recurrence, including the schedule for achieving conformance with 40 CFR Part 190 and with associated license conditions.

(d) For holders of an operating license for a nuclear power plant, the incidents included in paragraphs (a) or (c) of this section must be reported in accordance

with the procedures described in paragraphs 50.73 (b), (c), (d), (e), and (g) of this chapter and must also include the information required by paragraphs (a) and (c) of this section. Incidents reported in accordance with § 50.73 of this chapter need not be reported by a duplicate report under paragraphs (a) or (c) of this section.

(e) All other licensees who make reports under paragraphs (a) or (c) of this section shall, within 30 days after learning of the overexposure or excessive level or concentration, make a report in writing to the U.S. Nuclear Regulatory Commission, Document Control Desk, Washington, D.C. 20555, with a copy to the appropriate NRC Regional Office listed in Appendix D of this part.

§ 20.406 [Reserved]

## § 20.407 Personnel monitoring reports.

Each person described in § 20.408 of this part shall, within the first quarter of each calendar year, submit to the Director, Office of Nuclear Regulatory Research, U.S. Nuclear Regulatory Commission, Washington, DC 20555, the reports specified in paragraphs (a) and (b) of this section, covering the preceding calendar year.<sup>1</sup>

(a) A report of either (1) the total number of individuals for whom personnel monitoring was required under § 20.202(a) or § 34.33(a) of this chapter during the calendar year; or (2) the total number of individuals for whom personnel monitoring was provided during the calendar year: *Provided, however, That such total includes at least the number of individuals required to be reported under paragraph (a)(1) of this section. The report shall indicate whether it is submitted in accordance with paragraph (a)(1) or (a)(2) of this section. If personnel monitoring was not required to be provided to any individual by the licensee under §§ 20.202(a) or 34.33(a) of this chapter during the calendar year, the licensee shall submit a negative report indicating that such personnel monitoring was not required.*

(b) A statistical summary report of the personnel monitoring information recorded by the licensee for individuals for whom personnel monitoring was either required or provided, as described in paragraph (a) of this section, indicating the number of individuals whose total whole body exposure recorded during the previous calendar

<sup>1</sup> A licensee whose license expires or terminates prior to, or on the last day of the calendar year, shall submit reports at the expiration or termination of the license, covering that part of the year during which the license was in effect.

year was in each of the following estimated exposure ranges:

Estimated whole body exposure range (rads)	Number of individuals in each range
No measurable exposure	
Measurable exposure less than 0.1	
0.1 to 0.25	
0.25 to 0.5	
0.5 to 0.75	
0.75 to 1	
1 to 2	
2 to 3	
3 to 4	
4 to 5	
5 to 6	
6 to 7	
7 to 8	
8 to 9	
9 to 10	
10 to 11	
11 to 12	
12+	

<sup>1</sup>Individual values exactly equal to the values separating exposure ranges shall be reported in the higher range.

The low exposure range data are required in order to obtain better information about the exposures actually recorded. This section does not require improved measurements.

## § 20.408 Reports of personnel monitoring on termination of employment or work.

(a) This section applies to each person licensed by the Commission to:

(1) Operate a nuclear reactor designed to produce electrical or heat energy pursuant to § 50.21(b) or § 50.22 of this chapter or a testing facility as defined in § 50.2(r) of this chapter;

(2) Possess or use byproduct material for purposes of radiography pursuant to Parts 30 and 34 of this chapter;

(3) Possess or use at any one time, for purposes of fuel processing, fabricating, or reprocessing, special nuclear material in a quantity exceeding 5,000 grams of contained uranium-235, uranium-233, or plutonium or any combination thereof pursuant to Part 70 of this chapter;

(4) Possess high-level radioactive waste at a geologic repository operations area pursuant to Part 60 of this chapter; or

(5) Possess spent fuel in an independent spent fuel storage installation (ISFSI) pursuant to Part 72 of this chapter; or

(6) Possess or use at any one time, for processing or manufacturing for distribution pursuant to Parts 30, 32, or 33 of this Chapter, byproduct material in quantities exceeding any one of the following quantities:

<sup>1</sup> A licensee whose license expires or terminates prior to, or on the last day of the calendar year, shall submit reports at the expiration or termination of the license, covering that part of the year during which the license was in effect.

# PART 20 • STANDARDS FOR PROTECTION AGAINST RADIATION

Radionuclide <sup>1</sup>	Quantity in curies
Cesium-137	1
Cobalt-60	1
Gold-198	100
Iodine-131	1
Iodine-192	10
Krypton-85	1,000
Promethium-147	10
Technetium-99m	1,000

<sup>1</sup>The Commission may require, as a license condition, or by rule, regulation or order pursuant to § 20.502, reports from licensees who are licensed to use radionuclides not on this list, in quantities sufficient to cause comparable radiation levels.

## § 20.409 Notifications and reports to individuals.

(a) Requirements for notifications and reports to individuals of exposure to radiation or radioactive material are specified in § 19.13 of this chapter.

(b) When a licensee is required pursuant to §§ 20.405 or 20.408 to report to the Commission the exposure of an individual to radiation or radioactive material, the licensee shall also notify the individual. Such notice shall be transmitted at a time not later than the transmittal to the Commission, and shall comply with the provisions of § 19.13(a) of this chapter.

(7) Receive radioactive waste from other persons for disposal under Part 61 of this chapter.

(b) When an individual terminates employment with a licensee described in paragraph (a) of this section, or an individual assigned to work in such a licensee's facility, but not employed by the licensee, completes the work assignment in the licensee's facility, the licensee shall furnish to the Director, Office of Nuclear Regulatory Research, U.S. Nuclear Regulatory Commission, Washington, DC 20555, a report of the individual's exposures to radiation and radioactive material, incurred during the period of employment or work assignment in the licensee's facility, containing information recorded by the licensee pursuant to §§ 20.401(a) and 20.108. Such report shall be furnished within 30 days after the exposure of the individual has been determined by the licensee or 90 days after the date of termination of employment or work assignment, whichever is earlier.

<sup>1</sup>The Commission will evaluate the data obtained for 1978 and 1979 pursuant to this paragraph, and the benefits derived therefrom and may take action, including publication of notice of proposed rulemaking, to extend or otherwise modify this reporting requirement.

## EXCEPTIONS AND ADDITIONAL REQUIREMENTS

### § 20.501 Applications for exemptions.

The Commission may, upon application by any licensee or upon its own initiative, grant such exemptions from the requirements of the regulations in this part as it determines are authorized by law and will not result in undue hazard to life or property.

### § 20.502 Additional requirements.

The Commission may, by rule, regulation, or order, impose upon any licensee such requirements, in addition to those established in the regulations in this part, as it deems appropriate or necessary to protect health or to minimize danger to life or property.

## ENFORCEMENT

### § 20.601 Violations.

An injunction or other court order may be obtained prohibiting any violation of any provision of the Atomic Energy Act of 1954, as amended, or Title II of the Energy Reorganization Act of 1974, or any regulation or order issued thereunder. A court order may be obtained for the payment of a civil penalty imposed pursuant to section 234 of the Act for violation of section 53, 57, 62, 63, 81, 82, 101, 103, 104, 107, or 109 of the Act, or section 206 of the Energy Reorganization Act of 1974, or any rule, regulation, or order issued thereunder, or any term, condition, or limitation of any license issued thereunder, or for any violation for which a license may be revoked under section 186 of the Act. Any person who willfully violates any provision of the Act or any regulation or order issued thereunder may be guilty of a crime and, upon conviction, may be punished by fine or imprisonment or both, as provided by law.

[Note removed 49 FR 19623]

# PART 20 • STANDARDS FOR PROTECTION AGAINST RADIATION

## APPENDIX A.—PROTECTION FACTORS FOR RESPIRATORS \*

Description <sup>1</sup>	Modes <sup>2</sup>	Protection factors <sup>3</sup>		Tested and certified equipment—National Institute for Occupational Safety and Health (NIOSH) tests for permeability
		Particulates only	Particulates, gases, and vapors <sup>4</sup>	
I. Air-purifying respirators <sup>5</sup>				
Facepiece half-mask <sup>6</sup>	NP	10		30 CFR Part 11, Subpart K.
Facepiece full	NP	50		
Facepiece half-mask, full, or hood	PP	1,000		
II. Atmosphere-supplying respirators				
1. Air-line respirator				
Facepiece half-mask	CF		1,000	30 CFR Part 11, Subpart J.
Facepiece half-mask	D		5	
Facepiece full	CF		5,000	
Facepiece full	D		5	
Facepiece full	PD		5,000	
Hood	CF		(1)	
Suit	CF		(1)	
2. Self-contained breathing apparatus (SCBA)				
Facepiece full	D		50	30 CFR Part 11, Subpart H.
Facepiece full	PD		10,000	
Facepiece full	PD		50	
III. Combination respirator: Any combination of air-purifying and atmosphere-supplying respirators.			10,000	30 CFR Part 11, § 11.83(b)

\* For use in the selection of respiratory protective devices to be used only where the contaminants have been identified and the concentrations (or possible concentrations) are known.  
<sup>1</sup> Only for shaver faces and where nothing interferes with the seal of airtighting components against the skin. Hoods and suits are accepted.  
<sup>2</sup> The mode symbols are defined as follows: CF = continuous flow; D = demand; NP = negative pressure (i.e., negative pressure during inhalation); PD = pressure demand; i.e., always positive pressure; PP = positive pressure; RD = demand; recirculating (closed circuit); RP = positive pressure; recirculating (closed circuit).

<sup>3</sup> The protection factor is a measure of the degree of protection afforded by a respirator defined as the ratio of the concentration of airborne radioactive material outside the respiratory protective equipment to that inside the equipment (usually inside the facepiece) under conditions of use. It is applied to the ambient airborne concentration to estimate the concentrations inhaled by the wearer according to the following formula:  
 Ambient airborne concentration  
 Concentration inhaled

Concentration inhaled = Ambient airborne concentration / Protection factor

<sup>4</sup> The protection factors apply

(a) Only to trained individuals wearing properly fitted respirators used and maintained under supervision in a well-planned respiratory protective program.

(b) For air-purifying respirators only where high efficiency particulate filters (above 99.97% removal efficiency by thermally generated 0.3 µm dioctyl phthalate (DOP) test) are used in atmospheres not deficient in oxygen and not containing radioactive gas or vapor respiratory hazards.

(c) No allowance is to be made for the use of sorbents against radioactive gases or vapors.

(d) For atmosphere-supplying respirators only when supplied with adequate respirable air. Respirable air shall be provided of the quality and quantity required in accordance with NIOSH/MSHA certification (described in 30 CFR Part 11). Oxygen and air shall not be used in the same apparatus.

<sup>5</sup> Excluding radioactive contaminants that present an absorption or submersion hazard. For inhaled acids, approximately one half of the intake occurs by absorption through the skin so that an overall protection factor of less than 2 is appropriate when atmosphere-supplying respirators are used to protect against inhaled acids. If the protection factor for a device is 5, the effective protection factor for inhaled acids is about 1.4. For devices with protection factors of 10 the effective factor for inhaled acids is about 1.7, and for devices with protection factors of 100 or more the effective factor for inhaled acids is about 1.9. Air-purifying respirators are not suitable for protection against inhaled acids. See also footnote 1 concerning supplied-air suits.

<sup>6</sup> Cartridges and canisters shall not be used beyond service-life limitations.

<sup>7</sup> Under certain conditions, this type of respirator is not satisfactory for use where it might be possible to use, e.g., if an accident or emergency were to occur for the ambient airborne concentration to reach instantaneous values greater than 10 times the ambient values in Table 1, Column 1 of Appendix B of this part. This type of respirator is not suitable for protection against plutonium or other high-activity materials. The risk shall be assessed for its use with instant smoke, prior to use, each time it is donned.

<sup>8</sup> Equipment shall be designed in a manner that ensures that proper air flow rates are maintained and calibrated air pressure gauges or flow measuring devices are used. A protection factor of no more than 1,000 may be used for tested and certified supplied-air hoods when a minimum air flow of 6 cubic feet per minute is maintained and calibrated air pressure gauges or flow measuring devices are used. A protection factor of up to 2,000 may be used for tested and certified hoods only when the air flow is maintained at the manufacturer's recommended minimum rate for the equipment, the rate is greater than 6 cubic feet per minute, and calibrated air pressure gauges or flow measuring devices are used.

<sup>9</sup> The design of the supplied-air hood or helmet (with a minimum flow of 6 cfm of air) may determine its overall efficiency and the protection it provides. For example, some hoods apply contaminated air into the breathing zone when the wearer works with hands-over-head. This aspiration may be overcome if a short cape-like extension to the hood is worn under a coat or overalls. Other innovations specified by the approval agency shall be considered before using a hood in certain types of atmospheres, such as the design and its permeability to the contaminant under conditions of use.

<sup>10</sup> Appropriate protection factors shall be determined (see 20.103(e)), taking into account the design of the suit and its permeability to the contaminant under conditions of use. There shall be a readily rescue person equipped with self-contained breathing apparatus and communications equipment whenever supplied-air suits are used.

<sup>11</sup> No approval schedule is currently available for the equipment. Equipment shall be evaluated by testing or on the basis of reliable test information.

<sup>12</sup> This type of respirator may provide greater protection and be used as an emergency device in unknown concentrations for protection against inhalation hazards. External radiation hazards and other innovations to permit exposure such as skin absorption shall be taken into account in these circumstances.

<sup>13</sup> Quaternary is testing and be performed on each individual and no more than 0.02% leakage is allowed with this type of apparatus. Permissible outward leakage of gas from this or any positive pressure self-contained breathing apparatus is unacceptable because service life will be reduced substantially. Special training in the use of the type of apparatus shall be provided to the wearer (see footnote 1).

<sup>14</sup> Protection factor for type and mode of operation as listed above.

**Note 1.—Protection factors for respirators,** as may be approved by the U.S. Bureau of Mines/National Institute for Occupational Safety and Health (NIOSH) according to applicable approvals for respirators for type and mode of use to protect against airborne radionuclides, may be used to the extent that they do not exceed the protection factors listed in this table. The protection factors listed in this table may not be appropriate to circumstances where chemical or other respiratory hazards exist in addition to radiological hazards. The selection and use of respirators for these circumstances should take into account applicable approvals of the U.S. Bureau of Mines/NIOSH.

**Note 2.—Radioactive contaminants for which the concentration values in Table 1, column 1, Appendix B of this part are based on internal dose due to inhalation may, in addition, present external exposure hazards at higher concentrations. Under these circumstances, limitations on occupancy may have to be governed by external dose limits.**

# PART 20 • STANDARDS FOR PROTECTION AGAINST RADIATION

## APPENDIX B

### Concentrations in Air and Water Above Natural Background

[See notes at end of appendix]

Element (atomic number)	Isotope <sup>1</sup>		Table I		Table II	
			Column 1	Column 2	Column 1	Column 2
			Air † (μCi/ml)	Water (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)
Actinium (89)	Ac 227	S	$2 \times 10^{-12}$	$6 \times 10^{-5}$	$8 \times 10^{-14}$	$2 \times 10^{-4}$
		I	$3 \times 10^{-11}$	$9 \times 10^{-3}$	$9 \times 10^{-13}$	$3 \times 10^{-4}$
	Ac 228	S	$8 \times 10^{-8}$	$3 \times 10^{-2}$	$3 \times 10^{-9}$	$9 \times 10^{-3}$
		I	$2 \times 10^{-8}$	$3 \times 10^{-2}$	$6 \times 10^{-10}$	$9 \times 10^{-3}$
Americium (95)	Am 241	S	$6 \times 10^{-12}$	$1 \times 10^{-4}$	$2 \times 10^{-12}$	$4 \times 10^{-4}$
		★ I	$1 \times 10^{-10}$	$8 \times 10^{-4}$	$4 \times 10^{-12}$	$3 \times 10^{-3}$
	Am 242m	S	$6 \times 10^{-12}$	$1 \times 10^{-4}$	$2 \times 10^{-12}$	$4 \times 10^{-4}$
		I	$3 \times 10^{-10}$	$3 \times 10^{-2}$	$9 \times 10^{-12}$	$9 \times 10^{-3}$
	Am 242	S	$4 \times 10^{-8}$	$4 \times 10^{-2}$	$1 \times 10^{-9}$	$1 \times 10^{-4}$
		I	$5 \times 10^{-8}$	$4 \times 10^{-2}$	$2 \times 10^{-9}$	$1 \times 10^{-4}$
	Am 243	S	$6 \times 10^{-12}$	$1 \times 10^{-4}$	$2 \times 10^{-12}$	$4 \times 10^{-4}$
		I	$1 \times 10^{-10}$	$8 \times 10^{-4}$	$4 \times 10^{-12}$	$3 \times 10^{-3}$
	Am 244	S	$4 \times 10^{-8}$	$1 \times 10^{-1}$	$1 \times 10^{-9}$	$5 \times 10^{-3}$
		I	$2 \times 10^{-7}$	$1 \times 10^{-1}$	$8 \times 10^{-9}$	$5 \times 10^{-3}$
Antimony (51)	Sb 122	S	$2 \times 10^{-7}$	$8 \times 10^{-4}$	$6 \times 10^{-9}$	$3 \times 10^{-3}$
		I	$1 \times 10^{-7}$	$8 \times 10^{-4}$	$5 \times 10^{-9}$	$3 \times 10^{-3}$
	Sb 124	S	$2 \times 10^{-7}$	$7 \times 10^{-4}$	$5 \times 10^{-9}$	$2 \times 10^{-3}$
		I	$2 \times 10^{-8}$	$7 \times 10^{-4}$	$7 \times 10^{-10}$	$2 \times 10^{-3}$
	Sb 125	S	$5 \times 10^{-7}$	$3 \times 10^{-3}$	$2 \times 10^{-8}$	$1 \times 10^{-4}$
		I	$3 \times 10^{-8}$	$3 \times 10^{-3}$	$9 \times 10^{-10}$	$1 \times 10^{-4}$
Argon (18)	A 37	Sub <sup>2</sup>	$6 \times 10^{-3}$		$1 \times 10^{-4}$	
	A 41	Sub	$2 \times 10^{-8}$		$4 \times 10^{-8}$	
Arsenic (33)	As 73	S	$2 \times 10^{-8}$	$1 \times 10^{-7}$	$7 \times 10^{-9}$	$5 \times 10^{-4}$
		I	$4 \times 10^{-7}$	$1 \times 10^{-7}$	$1 \times 10^{-8}$	$5 \times 10^{-4}$
	As 74	S	$3 \times 10^{-7}$	$2 \times 10^{-3}$	$1 \times 10^{-8}$	$5 \times 10^{-3}$
		I	$1 \times 10^{-7}$	$2 \times 10^{-3}$	$4 \times 10^{-9}$	$5 \times 10^{-3}$
	As 76	S	$1 \times 10^{-7}$	$6 \times 10^{-4}$	$4 \times 10^{-9}$	$2 \times 10^{-3}$
		I	$1 \times 10^{-7}$	$6 \times 10^{-4}$	$3 \times 10^{-9}$	$2 \times 10^{-3}$
	As 77	S	$5 \times 10^{-7}$	$2 \times 10^{-3}$	$2 \times 10^{-8}$	$8 \times 10^{-3}$
		I	$4 \times 10^{-7}$	$2 \times 10^{-3}$	$1 \times 10^{-8}$	$8 \times 10^{-3}$
Astatine (85)	At 211	S	$7 \times 10^{-9}$	$5 \times 10^{-3}$	$2 \times 10^{-10}$	$2 \times 10^{-4}$
		I	$3 \times 10^{-8}$	$2 \times 10^{-3}$	$1 \times 10^{-9}$	$7 \times 10^{-3}$
Barium (56)	Ba 131	S	$1 \times 10^{-8}$	$5 \times 10^{-3}$	$4 \times 10^{-9}$	$2 \times 10^{-4}$
		I	$4 \times 10^{-7}$	$5 \times 10^{-3}$	$1 \times 10^{-8}$	$2 \times 10^{-4}$
	Ba 140	S	$1 \times 10^{-7}$	$8 \times 10^{-4}$	$4 \times 10^{-9}$	$3 \times 10^{-3}$
		I	$4 \times 10^{-8}$	$7 \times 10^{-4}$	$1 \times 10^{-8}$	$2 \times 10^{-3}$
Berkelium (97)	Bk 249	S	$9 \times 10^{-10}$	$2 \times 10^{-2}$	$3 \times 10^{-11}$	$6 \times 10^{-4}$
		I	$1 \times 10^{-7}$	$2 \times 10^{-2}$	$4 \times 10^{-9}$	$6 \times 10^{-4}$
	Bk 250	S	$1 \times 10^{-7}$	$6 \times 10^{-2}$	$5 \times 10^{-9}$	$2 \times 10^{-4}$
		I	$1 \times 10^{-8}$	$6 \times 10^{-2}$	$4 \times 10^{-9}$	$2 \times 10^{-4}$
Beryllium (4)	Be 7	S	$6 \times 10^{-8}$	$5 \times 10^{-2}$	$2 \times 10^{-7}$	$2 \times 10^{-3}$
		I	$1 \times 10^{-8}$	$5 \times 10^{-2}$	$4 \times 10^{-8}$	$2 \times 10^{-3}$
Bismuth (83)	Bi 206	S	$2 \times 10^{-7}$	$1 \times 10^{-2}$	$6 \times 10^{-8}$	$4 \times 10^{-3}$
		I	$1 \times 10^{-7}$	$1 \times 10^{-2}$	$5 \times 10^{-8}$	$4 \times 10^{-3}$
	Bi 207	S	$2 \times 10^{-7}$	$2 \times 10^{-2}$	$6 \times 10^{-8}$	$6 \times 10^{-3}$
		I	$1 \times 10^{-8}$	$2 \times 10^{-2}$	$5 \times 10^{-10}$	$6 \times 10^{-3}$
	Bi 210	S	$6 \times 10^{-8}$	$1 \times 10^{-1}$	$2 \times 10^{-10}$	$4 \times 10^{-3}$
		I	$6 \times 10^{-8}$	$1 \times 10^{-1}$	$2 \times 10^{-10}$	$4 \times 10^{-3}$
	Bi 212	S	$1 \times 10^{-7}$	$1 \times 10^{-2}$	$3 \times 10^{-8}$	$4 \times 10^{-4}$
		I	$2 \times 10^{-7}$	$1 \times 10^{-2}$	$7 \times 10^{-9}$	$4 \times 10^{-4}$

25 FR 10914



# PART 20 • STANDARDS FOR PROTECTION AGAINST RADIATION

## APPENDIX B

### Concentrations in Air and Water Above Natural Background—Continued

(See notes at end of appendix)

Element (atomic number)	Isotope <sup>1</sup>		Table I		Table II	
			Column 1	Column 2	Column 1	Column 2
			Air † (μCi/ml)	Water (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)
Bromine (35)	Br 82	S	1 × 10 <sup>-8</sup>	8 × 10 <sup>-3</sup>	4 × 10 <sup>-8</sup>	3 × 10 <sup>-4</sup>
		I	2 × 10 <sup>-7</sup>	1 × 10 <sup>-2</sup>	6 × 10 <sup>-8</sup>	4 × 10 <sup>-3</sup>
Cadmium (48)	Cd 109	S	5 × 10 <sup>-8</sup>	5 × 10 <sup>-3</sup>	2 × 10 <sup>-8</sup>	2 × 10 <sup>-4</sup>
		I	7 × 10 <sup>-8</sup>	5 × 10 <sup>-3</sup>	3 × 10 <sup>-8</sup>	2 × 10 <sup>-4</sup>
	Cd 115m	S	4 × 10 <sup>-8</sup>	7 × 10 <sup>-4</sup>	1 × 10 <sup>-8</sup>	3 × 10 <sup>-3</sup>
		I	4 × 10 <sup>-8</sup>	7 × 10 <sup>-4</sup>	1 × 10 <sup>-8</sup>	3 × 10 <sup>-3</sup>
	Cd 115	S	2 × 10 <sup>-7</sup>	1 × 10 <sup>-3</sup>	8 × 10 <sup>-8</sup>	3 × 10 <sup>-3</sup>
		I	2 × 10 <sup>-7</sup>	1 × 10 <sup>-3</sup>	6 × 10 <sup>-8</sup>	4 × 10 <sup>-3</sup>
Calcium (20)	Ca 45	S	3 × 10 <sup>-8</sup>	3 × 10 <sup>-3</sup>	1 × 10 <sup>-8</sup>	9 × 10 <sup>-4</sup>
		I	1 × 10 <sup>-7</sup>	5 × 10 <sup>-3</sup>	4 × 10 <sup>-8</sup>	2 × 10 <sup>-4</sup>
	Ca 47	S	2 × 10 <sup>-7</sup>	1 × 10 <sup>-3</sup>	6 × 10 <sup>-8</sup>	5 × 10 <sup>-3</sup>
		I	2 × 10 <sup>-7</sup>	1 × 10 <sup>-3</sup>	6 × 10 <sup>-8</sup>	3 × 10 <sup>-3</sup>
Californium (98)	Cf 249	S	2 × 10 <sup>-12</sup>	1 × 10 <sup>-4</sup>	5 × 10 <sup>-13</sup>	4 × 10 <sup>-5</sup>
		I	1 × 10 <sup>-10</sup>	7 × 10 <sup>-4</sup>	3 × 10 <sup>-12</sup>	2 × 10 <sup>-5</sup>
	Cf 250	S	5 × 10 <sup>-12</sup>	4 × 10 <sup>-4</sup>	2 × 10 <sup>-12</sup>	1 × 10 <sup>-5</sup>
		I	1 × 10 <sup>-10</sup>	7 × 10 <sup>-4</sup>	3 × 10 <sup>-12</sup>	3 × 10 <sup>-5</sup>
	Cf 251	S	2 × 10 <sup>-12</sup>	1 × 10 <sup>-4</sup>	6 × 10 <sup>-13</sup>	4 × 10 <sup>-5</sup>
		I	1 × 10 <sup>-10</sup>	8 × 10 <sup>-4</sup>	3 × 10 <sup>-12</sup>	3 × 10 <sup>-5</sup>
	Cf 252	S	6 × 10 <sup>-12</sup>	2 × 10 <sup>-4</sup>	2 × 10 <sup>-12</sup>	7 × 10 <sup>-5</sup>
		I	3 × 10 <sup>-11</sup>	2 × 10 <sup>-4</sup>	1 × 10 <sup>-12</sup>	7 × 10 <sup>-5</sup>
	Cf 253	S	8 × 10 <sup>-10</sup>	4 × 10 <sup>-3</sup>	3 × 10 <sup>-11</sup>	1 × 10 <sup>-4</sup>
		I	8 × 10 <sup>-10</sup>	4 × 10 <sup>-3</sup>	3 × 10 <sup>-11</sup>	1 × 10 <sup>-4</sup>
	Cf 254	S	5 × 10 <sup>-12</sup>	4 × 10 <sup>-4</sup>	2 × 10 <sup>-12</sup>	1 × 10 <sup>-5</sup>
		I	5 × 10 <sup>-12</sup>	4 × 10 <sup>-4</sup>	2 × 10 <sup>-12</sup>	1 × 10 <sup>-5</sup>
Carbon (6)	C 14	S	4 × 10 <sup>-8</sup>	2 × 10 <sup>-2</sup>	1 × 10 <sup>-7</sup>	8 × 10 <sup>-4</sup>
	(CO <sub>2</sub> )	Sub	5 × 10 <sup>-3</sup>		1 × 10 <sup>-8</sup>	
Curium (96)	Cm 141	S	4 × 10 <sup>-7</sup>	3 × 10 <sup>-3</sup>	2 × 10 <sup>-8</sup>	9 × 10 <sup>-3</sup>
		I	2 × 10 <sup>-7</sup>	3 × 10 <sup>-3</sup>	5 × 10 <sup>-8</sup>	9 × 10 <sup>-3</sup>
	Cm 143	S	3 × 10 <sup>-7</sup>	1 × 10 <sup>-3</sup>	9 × 10 <sup>-8</sup>	4 × 10 <sup>-3</sup>
		I	2 × 10 <sup>-7</sup>	1 × 10 <sup>-3</sup>	7 × 10 <sup>-8</sup>	4 × 10 <sup>-3</sup>
	Cm 144	S	1 × 10 <sup>-8</sup>	3 × 10 <sup>-4</sup>	3 × 10 <sup>-10</sup>	1 × 10 <sup>-3</sup>
		I	6 × 10 <sup>-9</sup>	3 × 10 <sup>-4</sup>	2 × 10 <sup>-10</sup>	1 × 10 <sup>-3</sup>
Cesium (55)	Cs 131	S	1 × 10 <sup>-3</sup>	7 × 10 <sup>-3</sup>	4 × 10 <sup>-7</sup>	2 × 10 <sup>-3</sup>
		I	3 × 10 <sup>-4</sup>	3 × 10 <sup>-3</sup>	1 × 10 <sup>-7</sup>	9 × 10 <sup>-4</sup>
	Cs 134m	S	4 × 10 <sup>-3</sup>	2 × 10 <sup>-1</sup>	1 × 10 <sup>-4</sup>	6 × 10 <sup>-3</sup>
		I	6 × 10 <sup>-4</sup>	3 × 10 <sup>-2</sup>	2 × 10 <sup>-7</sup>	1 × 10 <sup>-3</sup>
	Cs 134	S	4 × 10 <sup>-8</sup>	3 × 10 <sup>-4</sup>	1 × 10 <sup>-8</sup>	9 × 10 <sup>-4</sup>
		I	1 × 10 <sup>-8</sup>	1 × 10 <sup>-3</sup>	4 × 10 <sup>-10</sup>	4 × 10 <sup>-3</sup>
	Cs 135	S	5 × 10 <sup>-7</sup>	3 × 10 <sup>-3</sup>	2 × 10 <sup>-8</sup>	1 × 10 <sup>-4</sup>
		I	9 × 10 <sup>-8</sup>	7 × 10 <sup>-3</sup>	3 × 10 <sup>-8</sup>	2 × 10 <sup>-4</sup>
	Cs 136	S	4 × 10 <sup>-7</sup>	2 × 10 <sup>-3</sup>	1 × 10 <sup>-8</sup>	9 × 10 <sup>-3</sup>
		I	2 × 10 <sup>-7</sup>	2 × 10 <sup>-3</sup>	6 × 10 <sup>-8</sup>	6 × 10 <sup>-3</sup>
	Cs 137	S	6 × 10 <sup>-8</sup>	4 × 10 <sup>-4</sup>	2 × 10 <sup>-8</sup>	2 × 10 <sup>-3</sup>
		I	1 × 10 <sup>-8</sup>	1 × 10 <sup>-3</sup>	5 × 10 <sup>-10</sup>	4 × 10 <sup>-3</sup>
Chlorine (17)	Cl 36	S	4 × 10 <sup>-7</sup>	2 × 10 <sup>-3</sup>	1 × 10 <sup>-7</sup>	8 × 10 <sup>-3</sup>
		I	2 × 10 <sup>-8</sup>	2 × 10 <sup>-3</sup>	8 × 10 <sup>-10</sup>	6 × 10 <sup>-3</sup>
	Cl 38	S	3 × 10 <sup>-8</sup>	1 × 10 <sup>-3</sup>	9 × 10 <sup>-9</sup>	4 × 10 <sup>-4</sup>
		I	2 × 10 <sup>-8</sup>	1 × 10 <sup>-3</sup>	7 × 10 <sup>-9</sup>	4 × 10 <sup>-4</sup>
Chromium (24)	Cr 51	S	1 × 10 <sup>-3</sup>	5 × 10 <sup>-3</sup>	4 × 10 <sup>-7</sup>	2 × 10 <sup>-3</sup>
		I	2 × 10 <sup>-4</sup>	5 × 10 <sup>-3</sup>	8 × 10 <sup>-8</sup>	2 × 10 <sup>-3</sup>

25 FR 10814



# PART 20 • STANDARDS FOR PROTECTION AGAINST RADIATION

## APPENDIX B

### Concentrations in Air and Water Above Natural Background—Continued

[See notes at end of appendix]

Element (atomic number)	Isotope <sup>1</sup>	Table I		Table II	
		Column 1	Column 2	Column 1	Column 2
		Air † (μCi/ml)		Water (μCi/ml)	
Cesium (55)	Cs 137	5	3 × 10 <sup>-4</sup>	1 × 10 <sup>-7</sup>	5 × 10 <sup>-4</sup>
	Cs 134m	1	2 × 10 <sup>-7</sup>	1 × 10 <sup>-7</sup>	4 × 10 <sup>-4</sup>
	Cs 137	1	2 × 10 <sup>-7</sup>	6 × 10 <sup>-7</sup>	3 × 10 <sup>-3</sup>
	Cs 134	1	9 × 10 <sup>-8</sup>	6 × 10 <sup>-7</sup>	2 × 10 <sup>-3</sup>
	Cs 138	1	8 × 10 <sup>-7</sup>	4 × 10 <sup>-7</sup>	1 × 10 <sup>-4</sup>
Copper (29)	Cu 64	5	3 × 10 <sup>-7</sup>	1 × 10 <sup>-7</sup>	5 × 10 <sup>-3</sup>
	Cu 64	1	9 × 10 <sup>-8</sup>	1 × 10 <sup>-7</sup>	3 × 10 <sup>-3</sup>
	Cu 64	1	2 × 10 <sup>-8</sup>	1 × 10 <sup>-7</sup>	3 × 10 <sup>-4</sup>
	Cu 64	1	1 × 10 <sup>-8</sup>	6 × 10 <sup>-8</sup>	2 × 10 <sup>-4</sup>
	Cu 64	1	1 × 10 <sup>-8</sup>	4 × 10 <sup>-8</sup>	2 × 10 <sup>-4</sup>
Curium (96)	Cm 242	5	1 × 10 <sup>-10</sup>	7 × 10 <sup>-13</sup>	2 × 10 <sup>-3</sup>
	Cm 242	1	2 × 10 <sup>-10</sup>	7 × 10 <sup>-13</sup>	2 × 10 <sup>-3</sup>
	Cm 243	5	6 × 10 <sup>-11</sup>	1 × 10 <sup>-13</sup>	5 × 10 <sup>-4</sup>
	Cm 243	1	1 × 10 <sup>-10</sup>	7 × 10 <sup>-13</sup>	2 × 10 <sup>-3</sup>
	Cm 244	5	9 × 10 <sup>-12</sup>	2 × 10 <sup>-13</sup>	7 × 10 <sup>-4</sup>
	Cm 244	1	1 × 10 <sup>-10</sup>	8 × 10 <sup>-13</sup>	3 × 10 <sup>-3</sup>
	Cm 245	5	5 × 10 <sup>-12</sup>	1 × 10 <sup>-13</sup>	4 × 10 <sup>-4</sup>
	Cm 245	1	1 × 10 <sup>-10</sup>	8 × 10 <sup>-13</sup>	3 × 10 <sup>-3</sup>
	Cm 246	5	5 × 10 <sup>-12</sup>	1 × 10 <sup>-13</sup>	4 × 10 <sup>-4</sup>
	Cm 246	1	1 × 10 <sup>-10</sup>	8 × 10 <sup>-13</sup>	3 × 10 <sup>-3</sup>
Dysprosium (64)	Dy 165	5	3 × 10 <sup>-4</sup>	1 × 10 <sup>-7</sup>	9 × 10 <sup>-4</sup>
	Dy 165	1	2 × 10 <sup>-4</sup>	1 × 10 <sup>-7</sup>	4 × 10 <sup>-4</sup>
	Dy 166	5	2 × 10 <sup>-7</sup>	1 × 10 <sup>-7</sup>	8 × 10 <sup>-4</sup>
	Dy 166	1	2 × 10 <sup>-7</sup>	1 × 10 <sup>-7</sup>	4 × 10 <sup>-3</sup>
	Dy 166	1	2 × 10 <sup>-7</sup>	1 × 10 <sup>-7</sup>	4 × 10 <sup>-3</sup>
	Dy 166	1	2 × 10 <sup>-7</sup>	1 × 10 <sup>-7</sup>	4 × 10 <sup>-3</sup>
	Dy 166	1	2 × 10 <sup>-7</sup>	1 × 10 <sup>-7</sup>	4 × 10 <sup>-3</sup>
	Dy 166	1	2 × 10 <sup>-7</sup>	1 × 10 <sup>-7</sup>	4 × 10 <sup>-3</sup>
	Dy 166	1	2 × 10 <sup>-7</sup>	1 × 10 <sup>-7</sup>	4 × 10 <sup>-3</sup>
	Dy 166	1	2 × 10 <sup>-7</sup>	1 × 10 <sup>-7</sup>	4 × 10 <sup>-3</sup>
Einsteinium (99)	Es 253	5	8 × 10 <sup>-12</sup>	7 × 10 <sup>-13</sup>	3 × 10 <sup>-3</sup>
	Es 253	1	6 × 10 <sup>-10</sup>	7 × 10 <sup>-13</sup>	2 × 10 <sup>-3</sup>
	Es 254m	5	5 × 10 <sup>-4</sup>	5 × 10 <sup>-4</sup>	2 × 10 <sup>-3</sup>
	Es 254m	1	6 × 10 <sup>-4</sup>	5 × 10 <sup>-4</sup>	2 × 10 <sup>-3</sup>
	Es 254	5	2 × 10 <sup>-11</sup>	4 × 10 <sup>-13</sup>	6 × 10 <sup>-3</sup>
Erbium (68)	Er 169	5	4 × 10 <sup>-10</sup>	4 × 10 <sup>-13</sup>	1 × 10 <sup>-3</sup>
	Er 169	1	5 × 10 <sup>-10</sup>	8 × 10 <sup>-13</sup>	3 × 10 <sup>-3</sup>
	Er 171	5	4 × 10 <sup>-7</sup>	3 × 10 <sup>-7</sup>	9 × 10 <sup>-3</sup>
	Er 171	1	7 × 10 <sup>-7</sup>	3 × 10 <sup>-7</sup>	1 × 10 <sup>-4</sup>
	Er 171	1	6 × 10 <sup>-7</sup>	3 × 10 <sup>-7</sup>	1 × 10 <sup>-4</sup>
Europium (63)	Eu 152	5	4 × 10 <sup>-7</sup>	2 × 10 <sup>-7</sup>	1 × 10 <sup>-4</sup>
	(T/2 = 9.2 hrs)	1	3 × 10 <sup>-7</sup>	2 × 10 <sup>-7</sup>	6 × 10 <sup>-3</sup>
	Eu 152	5	1 × 10 <sup>-8</sup>	2 × 10 <sup>-7</sup>	4 × 10 <sup>-3</sup>
	(T/2 = 13 yrs)	1	2 × 10 <sup>-8</sup>	2 × 10 <sup>-7</sup>	8 × 10 <sup>-3</sup>
	Eu 154	5	4 × 10 <sup>-9</sup>	6 × 10 <sup>-8</sup>	2 × 10 <sup>-3</sup>
	Eu 154	1	7 × 10 <sup>-9</sup>	6 × 10 <sup>-8</sup>	2 × 10 <sup>-3</sup>
	Eu 155	5	9 × 10 <sup>-9</sup>	6 × 10 <sup>-8</sup>	3 × 10 <sup>-3</sup>
	Eu 155	1	7 × 10 <sup>-9</sup>	6 × 10 <sup>-8</sup>	2 × 10 <sup>-3</sup>

# PART 20 • STANDARDS FOR PROTECTION AGAINST RADIATION

## APPENDIX B

### Concentrations in Air and Water Above Natural Background—Continued

[See notes at end of appendix]

Element (atomic number)	Isotope <sup>1</sup>		Table I		Table II	
			Column 1	Column 2	Column 1	Column 2
			Air † (μCi/ml)	Water (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)
Fermium (100)	Fm 254	S	$6 \times 10^{-8}$	$4 \times 10^{-7}$	$2 \times 10^{-8}$	$1 \times 10^{-7}$
		I	$7 \times 10^{-8}$	$4 \times 10^{-7}$	$2 \times 10^{-8}$	$1 \times 10^{-7}$
	Fm 255	S	$2 \times 10^{-8}$	$1 \times 10^{-7}$	$4 \times 10^{-10}$	$3 \times 10^{-9}$
		I	$1 \times 10^{-8}$	$1 \times 10^{-7}$	$4 \times 10^{-10}$	$3 \times 10^{-9}$
Fluorine (9)	F 18	S	$2 \times 10^{-8}$	$3 \times 10^{-7}$	$1 \times 10^{-10}$	$9 \times 10^{-9}$
		I	$5 \times 10^{-8}$	$2 \times 10^{-7}$	$6 \times 10^{-11}$	$5 \times 10^{-9}$
		I	$3 \times 10^{-8}$	$1 \times 10^{-7}$	$9 \times 10^{-11}$	$3 \times 10^{-9}$
		I	$2 \times 10^{-7}$	$6 \times 10^{-7}$	$8 \times 10^{-9}$	$2 \times 10^{-8}$
Gadolinium (64)	Gd 153	S	$9 \times 10^{-8}$	$6 \times 10^{-7}$	$3 \times 10^{-9}$	$2 \times 10^{-8}$
		I	$5 \times 10^{-7}$	$2 \times 10^{-7}$	$2 \times 10^{-9}$	$8 \times 10^{-9}$
	Gd 159	S	$4 \times 10^{-7}$	$2 \times 10^{-7}$	$1 \times 10^{-9}$	$8 \times 10^{-9}$
		I	$2 \times 10^{-7}$	$1 \times 10^{-7}$	$8 \times 10^{-9}$	$4 \times 10^{-9}$
Gallium (31)	Ga 72	S	$2 \times 10^{-7}$	$1 \times 10^{-7}$	$6 \times 10^{-9}$	$4 \times 10^{-9}$
		I	$1 \times 10^{-7}$	$5 \times 10^{-8}$	$4 \times 10^{-9}$	$2 \times 10^{-9}$
		I	$6 \times 10^{-8}$	$5 \times 10^{-8}$	$2 \times 10^{-9}$	$2 \times 10^{-9}$
		I	$1 \times 10^{-8}$	$5 \times 10^{-8}$	$4 \times 10^{-9}$	$2 \times 10^{-9}$
Germanium (32)	Ge 71	S	$2 \times 10^{-7}$	$1 \times 10^{-7}$	$2 \times 10^{-9}$	$2 \times 10^{-9}$
		I	$6 \times 10^{-8}$	$5 \times 10^{-8}$	$2 \times 10^{-9}$	$2 \times 10^{-9}$
		I	$1 \times 10^{-8}$	$5 \times 10^{-8}$	$2 \times 10^{-9}$	$2 \times 10^{-9}$
		I	$2 \times 10^{-7}$	$1 \times 10^{-7}$	$8 \times 10^{-9}$	$5 \times 10^{-9}$
Gold (79)	Au 196	S	$6 \times 10^{-8}$	$4 \times 10^{-7}$	$2 \times 10^{-9}$	$1 \times 10^{-8}$
		I	$3 \times 10^{-7}$	$2 \times 10^{-7}$	$1 \times 10^{-9}$	$5 \times 10^{-9}$
		I	$2 \times 10^{-7}$	$1 \times 10^{-7}$	$8 \times 10^{-9}$	$5 \times 10^{-9}$
		I	$1 \times 10^{-8}$	$5 \times 10^{-8}$	$5 \times 10^{-9}$	$2 \times 10^{-9}$
Holmium (72)	Hf 181	S	$8 \times 10^{-8}$	$4 \times 10^{-7}$	$3 \times 10^{-9}$	$2 \times 10^{-8}$
		I	$4 \times 10^{-8}$	$2 \times 10^{-7}$	$1 \times 10^{-9}$	$7 \times 10^{-9}$
		I	$7 \times 10^{-8}$	$2 \times 10^{-7}$	$3 \times 10^{-9}$	$7 \times 10^{-9}$
		I	$2 \times 10^{-7}$	$9 \times 10^{-8}$	$7 \times 10^{-9}$	$3 \times 10^{-8}$
Helium (67)	He 166	S	$2 \times 10^{-7}$	$9 \times 10^{-8}$	$6 \times 10^{-9}$	$3 \times 10^{-8}$
		I	$2 \times 10^{-7}$	$9 \times 10^{-8}$	$6 \times 10^{-9}$	$3 \times 10^{-8}$
		I	$5 \times 10^{-8}$	$1 \times 10^{-7}$	$2 \times 10^{-9}$	$3 \times 10^{-8}$
		I	$5 \times 10^{-8}$	$1 \times 10^{-7}$	$2 \times 10^{-9}$	$3 \times 10^{-8}$
Hydrogen (1)	H2	S	$2 \times 10^{-7}$	$1 \times 10^{-7}$	$4 \times 10^{-9}$	$1 \times 10^{-8}$
		I	$8 \times 10^{-8}$	$4 \times 10^{-7}$	$3 \times 10^{-9}$	$1 \times 10^{-8}$
		I	$7 \times 10^{-8}$	$4 \times 10^{-7}$	$2 \times 10^{-9}$	$1 \times 10^{-8}$
		I	$2 \times 10^{-7}$	$1 \times 10^{-7}$	$2 \times 10^{-9}$	$1 \times 10^{-8}$
Indium (49)	In 113m	S	$2 \times 10^{-7}$	$1 \times 10^{-7}$	$2 \times 10^{-9}$	$1 \times 10^{-8}$
		I	$8 \times 10^{-8}$	$4 \times 10^{-7}$	$3 \times 10^{-9}$	$1 \times 10^{-8}$
	In 114m	S	$7 \times 10^{-8}$	$4 \times 10^{-7}$	$2 \times 10^{-9}$	$1 \times 10^{-8}$
		I	$1 \times 10^{-7}$	$5 \times 10^{-8}$	$4 \times 10^{-9}$	$2 \times 10^{-8}$
Iodine (53)	In 115m	S	$2 \times 10^{-7}$	$1 \times 10^{-7}$	$7 \times 10^{-10}$	$2 \times 10^{-9}$
		I	$2 \times 10^{-7}$	$1 \times 10^{-7}$	$8 \times 10^{-10}$	$4 \times 10^{-9}$
		I	$2 \times 10^{-7}$	$1 \times 10^{-7}$	$6 \times 10^{-10}$	$4 \times 10^{-9}$
		I	$2 \times 10^{-7}$	$1 \times 10^{-7}$	$6 \times 10^{-10}$	$4 \times 10^{-9}$
	In 115	S	$2 \times 10^{-7}$	$3 \times 10^{-7}$	$9 \times 10^{-10}$	$9 \times 10^{-9}$
		I	$3 \times 10^{-7}$	$3 \times 10^{-7}$	$1 \times 10^{-9}$	$9 \times 10^{-9}$
		I	$5 \times 10^{-8}$	$4 \times 10^{-7}$	$8 \times 10^{-11}$	$2 \times 10^{-9}$
		I	$2 \times 10^{-7}$	$6 \times 10^{-7}$	$6 \times 10^{-10}$	$2 \times 10^{-9}$
	I 126	S	$8 \times 10^{-8}$	$5 \times 10^{-7}$	$9 \times 10^{-11}$	$3 \times 10^{-9}$
		I	$3 \times 10^{-7}$	$3 \times 10^{-7}$	$1 \times 10^{-9}$	$9 \times 10^{-9}$
		I	$2 \times 10^{-7}$	$1 \times 10^{-7}$	$2 \times 10^{-11}$	$6 \times 10^{-9}$
		I	$7 \times 10^{-8}$	$6 \times 10^{-7}$	$2 \times 10^{-10}$	$2 \times 10^{-9}$
	I 131	S	$9 \times 10^{-8}$	$6 \times 10^{-7}$	$1 \times 10^{-10}$	$3 \times 10^{-9}$
		I	$3 \times 10^{-7}$	$2 \times 10^{-7}$	$1 \times 10^{-9}$	$6 \times 10^{-9}$
		I	$2 \times 10^{-7}$	$2 \times 10^{-7}$	$3 \times 10^{-9}$	$8 \times 10^{-9}$
		I	$9 \times 10^{-8}$	$5 \times 10^{-7}$	$3 \times 10^{-9}$	$2 \times 10^{-9}$
	I 132	S	$3 \times 10^{-8}$	$2 \times 10^{-7}$	$4 \times 10^{-10}$	$1 \times 10^{-9}$
		I	$2 \times 10^{-7}$	$1 \times 10^{-7}$	$7 \times 10^{-9}$	$4 \times 10^{-9}$
		I	$2 \times 10^{-7}$	$1 \times 10^{-7}$	$7 \times 10^{-9}$	$4 \times 10^{-9}$
		I	$5 \times 10^{-8}$	$4 \times 10^{-7}$	$6 \times 10^{-9}$	$2 \times 10^{-9}$

# PART 20 • STANDARDS FOR PROTECTION AGAINST RADIATION

## APPENDIX B

Concentrations in Air and Water Above Natural Background—Continued

[See notes at end of appendix.]

PR 10594

Element (atomic number)	Isotope <sup>1</sup>		Table I		Table II	
			Column 1	Column 2	Column 1	Column 2
			Air	Water	Air	Water
			† (μCi/ml)(μCi/ml)(μCi/ml)(μCi/ml)			
Iodine (52)	I 134	I	$3 \times 10^{-4}$	$2 \times 10^{-7}$	$1 \times 10^{-7}$	$6 \times 10^{-4}$
	I 135	S	$1 \times 10^{-7}$	$7 \times 10^{-4}$	$1 \times 10^{-9}$	$4 \times 10^{-4}$
	I	I	$4 \times 10^{-7}$	$2 \times 10^{-3}$	$1 \times 10^{-9}$	$7 \times 10^{-7}$
Iridium (77)	Ir 190	S	$1 \times 10^{-4}$	$6 \times 10^{-3}$	$4 \times 10^{-9}$	$2 \times 10^{-4}$
	I	I	$4 \times 10^{-7}$	$5 \times 10^{-3}$	$1 \times 10^{-9}$	$5 \times 10^{-4}$
	Ir 192	S	$1 \times 10^{-7}$	$1 \times 10^{-3}$	$4 \times 10^{-9}$	$4 \times 10^{-3}$
	I	I	$3 \times 10^{-9}$	$1 \times 10^{-3}$	$9 \times 10^{-10}$	$4 \times 10^{-3}$
	Ir 194	S	$2 \times 10^{-7}$	$1 \times 10^{-3}$	$8 \times 10^{-9}$	$2 \times 10^{-3}$
I	I	$2 \times 10^{-7}$	$9 \times 10^{-4}$	$5 \times 10^{-9}$	$3 \times 10^{-3}$	
Iron (26)	Fe 55	S	$9 \times 10^{-7}$	$2 \times 10^{-2}$	$3 \times 10^{-9}$	$8 \times 10^{-4}$
	I	I	$1 \times 10^{-4}$	$7 \times 10^{-7}$	$3 \times 10^{-9}$	$2 \times 10^{-3}$
	Fe 59	S	$1 \times 10^{-7}$	$2 \times 10^{-3}$	$5 \times 10^{-9}$	$6 \times 10^{-3}$
I	I	$5 \times 10^{-4}$	$2 \times 10^{-3}$	$2 \times 10^{-9}$	$5 \times 10^{-3}$	
Krypton (36)	Kr 85m	Sub	$6 \times 10^{-4}$		$1 \times 10^{-7}$	
	Kr 85	Sub	$1 \times 10^{-2}$		$3 \times 10^{-7}$	
	Kr 87	Sub	$1 \times 10^{-4}$		$2 \times 10^{-9}$	
	Kr 88	Sub	$1 \times 10^{-4}$		$2 \times 10^{-9}$	
Lanthanum (57)	La 140	S	$2 \times 10^{-7}$	$7 \times 10^{-4}$	$5 \times 10^{-9}$	$2 \times 10^{-3}$
	I	I	$1 \times 10^{-7}$	$7 \times 10^{-4}$	$4 \times 10^{-9}$	$2 \times 10^{-3}$
Lead (82)	Pb 203	S	$3 \times 10^{-4}$	$1 \times 10^{-3}$	$9 \times 10^{-9}$	$4 \times 10^{-4}$
	I	I	$2 \times 10^{-9}$	$1 \times 10^{-3}$	$6 \times 10^{-9}$	$4 \times 10^{-4}$
	Pb 210	S	$1 \times 10^{-10}$	$4 \times 10^{-4}$	$4 \times 10^{-12}$	$1 \times 10^{-7}$
	I	I	$2 \times 10^{-10}$	$5 \times 10^{-3}$	$8 \times 10^{-12}$	$2 \times 10^{-4}$
	Pb 212	S	$2 \times 10^{-9}$	$6 \times 10^{-4}$	$6 \times 10^{-10}$	$2 \times 10^{-3}$
I	I	$2 \times 10^{-9}$	$5 \times 10^{-4}$	$7 \times 10^{-10}$	$2 \times 10^{-3}$	
Lutetium (71)	Lu 177	S	$6 \times 10^{-7}$	$3 \times 10^{-3}$	$2 \times 10^{-9}$	$1 \times 10^{-4}$
	I	I	$5 \times 10^{-7}$	$3 \times 10^{-3}$	$2 \times 10^{-9}$	$1 \times 10^{-4}$
Manganese (25)	Mn 52	S	$2 \times 10^{-7}$	$1 \times 10^{-3}$	$7 \times 10^{-9}$	$3 \times 10^{-3}$
	I	I	$1 \times 10^{-7}$	$9 \times 10^{-4}$	$5 \times 10^{-9}$	$3 \times 10^{-3}$
	Mn 54	S	$4 \times 10^{-7}$	$4 \times 10^{-3}$	$1 \times 10^{-9}$	$1 \times 10^{-4}$
	I	I	$4 \times 10^{-9}$	$3 \times 10^{-3}$	$1 \times 10^{-9}$	$1 \times 10^{-4}$
Mercury (80)	Mn 56	S	$8 \times 10^{-7}$	$4 \times 10^{-3}$	$3 \times 10^{-9}$	$1 \times 10^{-4}$
	I	I	$3 \times 10^{-7}$	$3 \times 10^{-3}$	$2 \times 10^{-9}$	$1 \times 10^{-4}$
	Hg 197m	S	$7 \times 10^{-7}$	$6 \times 10^{-3}$	$3 \times 10^{-9}$	$2 \times 10^{-4}$
	I	I	$8 \times 10^{-7}$	$5 \times 10^{-3}$	$3 \times 10^{-9}$	$2 \times 10^{-4}$
Hg 197	S	S	$1 \times 10^{-4}$	$9 \times 10^{-3}$	$4 \times 10^{-9}$	$3 \times 10^{-4}$
	I	I	$3 \times 10^{-4}$	$1 \times 10^{-3}$	$9 \times 10^{-9}$	$5 \times 10^{-4}$
	S	S	$7 \times 10^{-4}$	$3 \times 10^{-3}$	$2 \times 10^{-9}$	$2 \times 10^{-4}$
Hg 203	I	I	$1 \times 10^{-7}$	$3 \times 10^{-3}$	$4 \times 10^{-9}$	$1 \times 10^{-4}$
	I	I	$7 \times 10^{-7}$	$5 \times 10^{-3}$	$3 \times 10^{-9}$	$2 \times 10^{-4}$
Molybdenum (42)	Mo 99	S	$7 \times 10^{-7}$	$5 \times 10^{-3}$	$3 \times 10^{-9}$	$2 \times 10^{-4}$
	I	I	$2 \times 10^{-7}$	$1 \times 10^{-3}$	$7 \times 10^{-9}$	$4 \times 10^{-3}$
Neodymium (60)	Nd 144	S	$8 \times 10^{-11}$	$2 \times 10^{-3}$	$3 \times 10^{-12}$	$7 \times 10^{-3}$
	I	I	$3 \times 10^{-10}$	$2 \times 10^{-3}$	$1 \times 10^{-11}$	$8 \times 10^{-3}$
	Nd 147	S	$4 \times 10^{-7}$	$2 \times 10^{-3}$	$1 \times 10^{-9}$	$6 \times 10^{-3}$
	I	I	$2 \times 10^{-7}$	$2 \times 10^{-3}$	$8 \times 10^{-9}$	$6 \times 10^{-3}$
Nd 149	S	S	$2 \times 10^{-4}$	$8 \times 10^{-3}$	$6 \times 10^{-9}$	$3 \times 10^{-4}$
	I	I	$1 \times 10^{-4}$	$8 \times 10^{-3}$	$5 \times 10^{-9}$	$3 \times 10^{-4}$

# PART 20 • STANDARDS FOR PROTECTION AGAINST RADIATION

## APPENDIX B

### Concentrations in Air and Water Above Natural Background—Continued

(See notes at end of appendix)

Element (atomic number)	Isotope <sup>1</sup>		Table I		Table II	
			Column 1	Column 2	Column 1	Column 2
			Air ( $\mu\text{Ci/ml}$ )	Water ( $\mu\text{Ci/ml}$ )	Air ( $\mu\text{Ci/ml}$ )	Water ( $\mu\text{Ci/ml}$ )
Neptunium (93)	Np 237	S	$4 \times 10^{-12}$	$9 \times 10^{-3}$	$1 \times 10^{-13}$	$3 \times 10^{-2}$
		I	$1 \times 10^{-10}$	$9 \times 10^{-4}$	$4 \times 10^{-12}$	$3 \times 10^{-3}$
	Np 239	S	$8 \times 10^{-7}$	$4 \times 10^{-3}$	$3 \times 10^{-9}$	$1 \times 10^{-4}$
Nickel (28)		I	$7 \times 10^{-7}$	$4 \times 10^{-3}$	$2 \times 10^{-9}$	$1 \times 10^{-4}$
	Ni 59	S	$5 \times 10^{-7}$	$6 \times 10^{-3}$	$3 \times 10^{-9}$	$2 \times 10^{-4}$
		I	$8 \times 10^{-7}$	$6 \times 10^{-3}$	$3 \times 10^{-9}$	$2 \times 10^{-4}$
	Ni 63	S	$6 \times 10^{-9}$	$8 \times 10^{-4}$	$2 \times 10^{-9}$	$3 \times 10^{-3}$
		I	$3 \times 10^{-7}$	$2 \times 10^{-3}$	$1 \times 10^{-9}$	$7 \times 10^{-4}$
Niobium (Columbium) (41)	Nb 93m	S	$9 \times 10^{-7}$	$4 \times 10^{-3}$	$3 \times 10^{-9}$	$1 \times 10^{-4}$
		I	$5 \times 10^{-7}$	$3 \times 10^{-3}$	$2 \times 10^{-9}$	$1 \times 10^{-4}$
	Nb 95	S	$1 \times 10^{-7}$	$1 \times 10^{-3}$	$4 \times 10^{-9}$	$4 \times 10^{-4}$
		I	$2 \times 10^{-7}$	$1 \times 10^{-3}$	$5 \times 10^{-9}$	$4 \times 10^{-4}$
	Nb 97	S	$5 \times 10^{-7}$	$3 \times 10^{-3}$	$2 \times 10^{-9}$	$1 \times 10^{-4}$
Osmium (76)		I	$6 \times 10^{-6}$	$3 \times 10^{-3}$	$3 \times 10^{-9}$	$1 \times 10^{-4}$
	Os 185	S	$5 \times 10^{-7}$	$2 \times 10^{-3}$	$2 \times 10^{-9}$	$9 \times 10^{-4}$
		I	$5 \times 10^{-8}$	$2 \times 10^{-3}$	$2 \times 10^{-9}$	$7 \times 10^{-4}$
	Os 191m	S	$2 \times 10^{-3}$	$7 \times 10^{-3}$	$6 \times 10^{-7}$	$3 \times 10^{-3}$
		I	$9 \times 10^{-4}$	$7 \times 10^{-3}$	$3 \times 10^{-7}$	$3 \times 10^{-3}$
Osmium (76)	Os 191	S	$1 \times 10^{-4}$	$5 \times 10^{-3}$	$4 \times 10^{-8}$	$2 \times 10^{-4}$
		I	$4 \times 10^{-7}$	$5 \times 10^{-3}$	$1 \times 10^{-8}$	$2 \times 10^{-4}$
	Os 193	S	$4 \times 10^{-7}$	$2 \times 10^{-3}$	$1 \times 10^{-8}$	$6 \times 10^{-4}$
		I	$3 \times 10^{-7}$	$2 \times 10^{-3}$	$9 \times 10^{-9}$	$5 \times 10^{-4}$
	Palladium (46)	S	$1 \times 10^{-6}$	$1 \times 10^{-3}$	$5 \times 10^{-9}$	$7 \times 10^{-4}$
Palladium (46)	Pd 103	S	$7 \times 10^{-7}$	$8 \times 10^{-3}$	$3 \times 10^{-9}$	$3 \times 10^{-4}$
		I	$6 \times 10^{-7}$	$3 \times 10^{-3}$	$2 \times 10^{-9}$	$9 \times 10^{-4}$
	Pd 109	S	$4 \times 10^{-7}$	$2 \times 10^{-3}$	$1 \times 10^{-9}$	$7 \times 10^{-4}$
Phosphorus (15)	P 32	S	$7 \times 10^{-8}$	$5 \times 10^{-3}$	$2 \times 10^{-9}$	$2 \times 10^{-4}$
		I	$8 \times 10^{-8}$	$7 \times 10^{-3}$	$3 \times 10^{-9}$	$3 \times 10^{-4}$
	Platinum (78)	S	$8 \times 10^{-7}$	$4 \times 10^{-3}$	$3 \times 10^{-9}$	$1 \times 10^{-4}$
Platinum (78)	Pt 191	S	$6 \times 10^{-7}$	$3 \times 10^{-3}$	$2 \times 10^{-9}$	$1 \times 10^{-4}$
		I	$7 \times 10^{-7}$	$3 \times 10^{-3}$	$2 \times 10^{-9}$	$1 \times 10^{-4}$
	Pt 193m	S	$5 \times 10^{-6}$	$3 \times 10^{-3}$	$2 \times 10^{-9}$	$1 \times 10^{-4}$
		I	$1 \times 10^{-7}$	$3 \times 10^{-3}$	$4 \times 10^{-9}$	$9 \times 10^{-4}$
	Pt 197m	S	$3 \times 10^{-7}$	$5 \times 10^{-3}$	$1 \times 10^{-9}$	$2 \times 10^{-4}$
Plutonium (94)		I	$6 \times 10^{-6}$	$3 \times 10^{-3}$	$2 \times 10^{-9}$	$1 \times 10^{-4}$
	Pu 238	S	$5 \times 10^{-7}$	$4 \times 10^{-3}$	$3 \times 10^{-9}$	$1 \times 10^{-4}$
		I	$2 \times 10^{-12}$	$1 \times 10^{-3}$	$7 \times 10^{-14}$	$5 \times 10^{-4}$
	Pu 239	S	$3 \times 10^{-11}$	$8 \times 10^{-3}$	$1 \times 10^{-12}$	$3 \times 10^{-3}$
		I	$2 \times 10^{-12}$	$1 \times 10^{-3}$	$6 \times 10^{-14}$	$5 \times 10^{-4}$
Plutonium (94)	Pu 240	S	$4 \times 10^{-11}$	$8 \times 10^{-3}$	$1 \times 10^{-12}$	$3 \times 10^{-3}$
		I	$2 \times 10^{-12}$	$1 \times 10^{-3}$	$4 \times 10^{-14}$	$5 \times 10^{-4}$
	Pu 241	S	$9 \times 10^{-11}$	$7 \times 10^{-3}$	$3 \times 10^{-12}$	$3 \times 10^{-3}$
		I	$4 \times 10^{-11}$	$4 \times 10^{-3}$	$1 \times 10^{-12}$	$2 \times 10^{-3}$

# PART 20 • STANDARDS FOR PROTECTION AGAINST RADIATION

## APPENDIX B

### Concentrations in Air and Water Above Natural Background—Continued

(See notes at end of appendix)

Element (atomic number)	Isotope <sup>1</sup>		Table I		Table II	
			Column 1	Column 2	Column 1	Column 2
			Air † (μCi/ml)	Water (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)
Plutonium (94)	Pu 242	S	2 × 10 <sup>-12</sup>	1 × 10 <sup>-4</sup>	6 × 10 <sup>-14</sup>	5 × 10 <sup>-2</sup>
	I		4 × 10 <sup>-11</sup>	9 × 10 <sup>-4</sup>	1 × 10 <sup>-12</sup>	3 × 10 <sup>-2</sup>
	Pu 243	S	2 × 10 <sup>-9</sup>	1 × 10 <sup>-3</sup>	6 × 10 <sup>-9</sup>	3 × 10 <sup>-4</sup>
	I		2 × 10 <sup>-8</sup>	1 × 10 <sup>-2</sup>	8 × 10 <sup>-9</sup>	3 × 10 <sup>-3</sup>
Polonium (84)	Po 244	S	2 × 10 <sup>-12</sup>	1 × 10 <sup>-4</sup>	6 × 10 <sup>-14</sup>	4 × 10 <sup>-2</sup>
	I		3 × 10 <sup>-11</sup>	3 × 10 <sup>-4</sup>	1 × 10 <sup>-12</sup>	1 × 10 <sup>-2</sup>
	Po 210	S	5 × 10 <sup>-10</sup>	2 × 10 <sup>-3</sup>	2 × 10 <sup>-11</sup>	7 × 10 <sup>-2</sup>
	I		2 × 10 <sup>-9</sup>	6 × 10 <sup>-3</sup>	7 × 10 <sup>-12</sup>	3 × 10 <sup>-2</sup>
Potassium (19)	K 42	S	2 × 10 <sup>-8</sup>	9 × 10 <sup>-3</sup>	7 × 10 <sup>-9</sup>	3 × 10 <sup>-4</sup>
	I		1 × 10 <sup>-7</sup>	6 × 10 <sup>-4</sup>	4 × 10 <sup>-9</sup>	2 × 10 <sup>-3</sup>
	Praseodymium (59)	Pr 142	2 × 10 <sup>-7</sup>	9 × 10 <sup>-4</sup>	7 × 10 <sup>-9</sup>	3 × 10 <sup>-2</sup>
	I		2 × 10 <sup>-7</sup>	9 × 10 <sup>-4</sup>	5 × 10 <sup>-9</sup>	3 × 10 <sup>-2</sup>
Promethium (61)	Pm 143	S	2 × 10 <sup>-7</sup>	1 × 10 <sup>-3</sup>	1 × 10 <sup>-8</sup>	5 × 10 <sup>-2</sup>
	I		2 × 10 <sup>-7</sup>	1 × 10 <sup>-3</sup>	4 × 10 <sup>-9</sup>	5 × 10 <sup>-2</sup>
	Pm 147	S	6 × 10 <sup>-9</sup>	6 × 10 <sup>-3</sup>	2 × 10 <sup>-9</sup>	2 × 10 <sup>-4</sup>
	I		1 × 10 <sup>-7</sup>	6 × 10 <sup>-3</sup>	3 × 10 <sup>-9</sup>	2 × 10 <sup>-4</sup>
Protactinium (91)	Pm 149	S	3 × 10 <sup>-7</sup>	1 × 10 <sup>-3</sup>	1 × 10 <sup>-8</sup>	4 × 10 <sup>-2</sup>
	I		2 × 10 <sup>-7</sup>	1 × 10 <sup>-3</sup>	8 × 10 <sup>-9</sup>	4 × 10 <sup>-2</sup>
	Pa 230	S	2 × 10 <sup>-9</sup>	7 × 10 <sup>-3</sup>	6 × 10 <sup>-11</sup>	2 × 10 <sup>-4</sup>
	I		8 × 10 <sup>-10</sup>	7 × 10 <sup>-3</sup>	3 × 10 <sup>-11</sup>	2 × 10 <sup>-4</sup>
Radium (88)	Pa 231	S	1 × 10 <sup>-12</sup>	3 × 10 <sup>-3</sup>	4 × 10 <sup>-14</sup>	9 × 10 <sup>-2</sup>
	I		1 × 10 <sup>-10</sup>	8 × 10 <sup>-4</sup>	4 × 10 <sup>-12</sup>	2 × 10 <sup>-2</sup>
	Pa 223	S	6 × 10 <sup>-7</sup>	4 × 10 <sup>-3</sup>	2 × 10 <sup>-8</sup>	1 × 10 <sup>-4</sup>
	I		2 × 10 <sup>-7</sup>	3 × 10 <sup>-3</sup>	6 × 10 <sup>-9</sup>	1 × 10 <sup>-4</sup>
Radium (88)	Ra 223	S	2 × 10 <sup>-9</sup>	2 × 10 <sup>-3</sup>	6 × 10 <sup>-11</sup>	7 × 10 <sup>-2</sup>
	I		2 × 10 <sup>-10</sup>	1 × 10 <sup>-4</sup>	8 × 10 <sup>-12</sup>	4 × 10 <sup>-4</sup>
	Ra 224	S	8 × 10 <sup>-9</sup>	7 × 10 <sup>-3</sup>	2 × 10 <sup>-10</sup>	2 × 10 <sup>-4</sup>
	I		7 × 10 <sup>-10</sup>	2 × 10 <sup>-4</sup>	2 × 10 <sup>-11</sup>	5 × 10 <sup>-4</sup>
Radium (88)	Ra 226	S	2 × 10 <sup>-11</sup>	4 × 10 <sup>-7</sup>	3 × 10 <sup>-12</sup>	3 × 10 <sup>-3</sup>
	I		5 × 10 <sup>-11</sup>	9 × 10 <sup>-4</sup>	2 × 10 <sup>-12</sup>	3 × 10 <sup>-3</sup>
	Ra 228	S	7 × 10 <sup>-11</sup>	8 × 10 <sup>-7</sup>	2 × 10 <sup>-12</sup>	3 × 10 <sup>-3</sup>
	I		4 × 10 <sup>-11</sup>	7 × 10 <sup>-4</sup>	1 × 10 <sup>-12</sup>	3 × 10 <sup>-3</sup>
Radon (86)	Rn 220	S	3 × 10 <sup>-7</sup>		1 × 10 <sup>-8</sup>	
	I					
	Rn 222	S	1 × 10 <sup>-6</sup>		3 × 10 <sup>-9</sup>	
	I					
Rhenium (75)	Ra 183	S	3 × 10 <sup>-4</sup>	2 × 10 <sup>-2</sup>	9 × 10 <sup>-4</sup>	6 × 10 <sup>-4</sup>
	I		2 × 10 <sup>-7</sup>	8 × 10 <sup>-3</sup>	5 × 10 <sup>-9</sup>	3 × 10 <sup>-4</sup>
	Ra 186	S	6 × 10 <sup>-7</sup>	3 × 10 <sup>-3</sup>	2 × 10 <sup>-8</sup>	9 × 10 <sup>-2</sup>
	I		2 × 10 <sup>-7</sup>	1 × 10 <sup>-3</sup>	8 × 10 <sup>-9</sup>	5 × 10 <sup>-2</sup>
Rhodium (45)	Ra 187	S	9 × 10 <sup>-4</sup>	7 × 10 <sup>-2</sup>	3 × 10 <sup>-7</sup>	2 × 10 <sup>-2</sup>
	I		5 × 10 <sup>-7</sup>	4 × 10 <sup>-3</sup>	2 × 10 <sup>-9</sup>	2 × 10 <sup>-3</sup>
	Ra 188	S	4 × 10 <sup>-7</sup>	2 × 10 <sup>-3</sup>	1 × 10 <sup>-8</sup>	6 × 10 <sup>-2</sup>
	I		2 × 10 <sup>-7</sup>	9 × 10 <sup>-4</sup>	6 × 10 <sup>-7</sup>	3 × 10 <sup>-2</sup>
Rubidium (37)	Rh 103m	S	8 × 10 <sup>-3</sup>	4 × 10 <sup>-1</sup>	3 × 10 <sup>-4</sup>	1 × 10 <sup>-2</sup>
	I		6 × 10 <sup>-3</sup>	3 × 10 <sup>-1</sup>	2 × 10 <sup>-4</sup>	1 × 10 <sup>-2</sup>
	Rh 105	S	8 × 10 <sup>-7</sup>	4 × 10 <sup>-3</sup>	3 × 10 <sup>-9</sup>	1 × 10 <sup>-4</sup>
	I		5 × 10 <sup>-7</sup>	3 × 10 <sup>-3</sup>	2 × 10 <sup>-9</sup>	1 × 10 <sup>-4</sup>
Rubidium (37)	Rb 86	S	3 × 10 <sup>-7</sup>	2 × 10 <sup>-3</sup>	1 × 10 <sup>-8</sup>	7 × 10 <sup>-2</sup>
	I		7 × 10 <sup>-8</sup>	7 × 10 <sup>-4</sup>	2 × 10 <sup>-9</sup>	2 × 10 <sup>-2</sup>
	Rb 87	S	8 × 10 <sup>-7</sup>	3 × 10 <sup>-3</sup>	2 × 10 <sup>-8</sup>	1 × 10 <sup>-4</sup>
	I		7 × 10 <sup>-8</sup>	2 × 10 <sup>-3</sup>	2 × 10 <sup>-9</sup>	2 × 10 <sup>-4</sup>



# PART 20 • STANDARDS FOR PROTECTION AGAINST RADIATION

## APPENDIX B

### Concentrations in Air and Water Above Natural Background—Continued

(See notes at end of appendix)

Element (atomic number)	Isotope		Table I		Table II	
			Column 1	Column 2	Column 1	Column 2
			Air + (μCi/ml)	Water (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)
Ruthenium (44)	Ru 97	5	$2 \times 10^{-6}$	$1 \times 10^{-7}$	$5 \times 10^{-6}$	$4 \times 10^{-6}$
		1	$2 \times 10^{-6}$	$1 \times 10^{-7}$	$4 \times 10^{-6}$	$3 \times 10^{-6}$
	Ru 103	5	$5 \times 10^{-7}$	$2 \times 10^{-7}$	$2 \times 10^{-6}$	$5 \times 10^{-7}$
		1	$8 \times 10^{-6}$	$2 \times 10^{-7}$	$2 \times 10^{-6}$	$5 \times 10^{-7}$
	Ru 105	5	$7 \times 10^{-7}$	$2 \times 10^{-7}$	$2 \times 10^{-6}$	$1 \times 10^{-6}$
Samarium (62)		1	$5 \times 10^{-7}$	$2 \times 10^{-7}$	$2 \times 10^{-6}$	$1 \times 10^{-6}$
	Ru 106	5	$8 \times 10^{-6}$	$4 \times 10^{-6}$	$2 \times 10^{-6}$	$1 \times 10^{-6}$
		1	$4 \times 10^{-6}$	$2 \times 10^{-6}$	$2 \times 10^{-6}$	$1 \times 10^{-6}$
	Sm 147	5	$7 \times 10^{-11}$	$2 \times 10^{-12}$	$2 \times 10^{-12}$	$6 \times 10^{-12}$
		1	$2 \times 10^{-10}$	$2 \times 10^{-12}$	$9 \times 10^{-12}$	$7 \times 10^{-12}$
Scandium (21)	Sm 151	5	$6 \times 10^{-11}$	$1 \times 10^{-12}$	$2 \times 10^{-12}$	$4 \times 10^{-12}$
		1	$1 \times 10^{-10}$	$1 \times 10^{-12}$	$5 \times 10^{-12}$	$4 \times 10^{-12}$
	Sm 153	5	$2 \times 10^{-10}$	$2 \times 10^{-12}$	$2 \times 10^{-12}$	$8 \times 10^{-12}$
		1	$4 \times 10^{-10}$	$2 \times 10^{-12}$	$1 \times 10^{-12}$	$8 \times 10^{-12}$
	Sc 46	5	$2 \times 10^{-7}$	$1 \times 10^{-7}$	$8 \times 10^{-8}$	$4 \times 10^{-7}$
Selenium (34)		1	$2 \times 10^{-6}$	$1 \times 10^{-7}$	$8 \times 10^{-8}$	$4 \times 10^{-7}$
	Se 47	5	$6 \times 10^{-7}$	$2 \times 10^{-7}$	$2 \times 10^{-7}$	$9 \times 10^{-7}$
		1	$5 \times 10^{-7}$	$2 \times 10^{-7}$	$2 \times 10^{-7}$	$9 \times 10^{-7}$
	Se 48	5	$2 \times 10^{-7}$	$8 \times 10^{-8}$	$6 \times 10^{-8}$	$2 \times 10^{-7}$
		1	$1 \times 10^{-7}$	$8 \times 10^{-8}$	$5 \times 10^{-8}$	$2 \times 10^{-7}$
Silver (47)	Se 75	5	$1 \times 10^{-6}$	$9 \times 10^{-7}$	$4 \times 10^{-7}$	$2 \times 10^{-7}$
		1	$1 \times 10^{-7}$	$8 \times 10^{-7}$	$4 \times 10^{-7}$	$2 \times 10^{-7}$
	Si 31	5	$4 \times 10^{-6}$	$3 \times 10^{-7}$	$2 \times 10^{-7}$	$9 \times 10^{-7}$
		1	$1 \times 10^{-6}$	$4 \times 10^{-7}$	$2 \times 10^{-7}$	$9 \times 10^{-7}$
	Ag 105	5	$6 \times 10^{-7}$	$2 \times 10^{-7}$	$2 \times 10^{-7}$	$1 \times 10^{-6}$
Sodium (11)		1	$8 \times 10^{-6}$	$2 \times 10^{-7}$	$2 \times 10^{-7}$	$1 \times 10^{-6}$
	Ag 110m	5	$2 \times 10^{-7}$	$9 \times 10^{-8}$	$7 \times 10^{-8}$	$2 \times 10^{-7}$
		1	$1 \times 10^{-6}$	$9 \times 10^{-8}$	$2 \times 10^{-7}$	$2 \times 10^{-7}$
	Ag 111	5	$2 \times 10^{-7}$	$1 \times 10^{-7}$	$1 \times 10^{-7}$	$4 \times 10^{-7}$
		1	$2 \times 10^{-7}$	$1 \times 10^{-7}$	$8 \times 10^{-8}$	$4 \times 10^{-7}$
Strontium (38)	Na 22	5	$2 \times 10^{-7}$	$1 \times 10^{-7}$	$6 \times 10^{-8}$	$4 \times 10^{-7}$
		1	$9 \times 10^{-6}$	$9 \times 10^{-8}$	$2 \times 10^{-7}$	$2 \times 10^{-7}$
	Na 24	5	$1 \times 10^{-6}$	$4 \times 10^{-7}$	$4 \times 10^{-7}$	$2 \times 10^{-7}$
		1	$1 \times 10^{-7}$	$8 \times 10^{-8}$	$5 \times 10^{-8}$	$3 \times 10^{-7}$
	Sr 83m	5	$4 \times 10^{-7}$	$2 \times 10^{-7}$	$1 \times 10^{-7}$	$7 \times 10^{-7}$
		1	$2 \times 10^{-7}$	$2 \times 10^{-7}$	$1 \times 10^{-7}$	$7 \times 10^{-7}$
	Sr 85	5	$2 \times 10^{-7}$	$2 \times 10^{-7}$	$8 \times 10^{-8}$	$1 \times 10^{-6}$
		1	$1 \times 10^{-7}$	$5 \times 10^{-8}$	$4 \times 10^{-8}$	$2 \times 10^{-6}$
	Sr 89	5	$2 \times 10^{-7}$	$2 \times 10^{-7}$	$2 \times 10^{-7}$	$2 \times 10^{-6}$
		1	$4 \times 10^{-6}$	$8 \times 10^{-8}$	$1 \times 10^{-7}$	$3 \times 10^{-7}$
	Sr 90	5	$1 \times 10^{-6}$	$1 \times 10^{-7}$	$2 \times 10^{-7}$	$2 \times 10^{-7}$
		1	$5 \times 10^{-6}$	$1 \times 10^{-7}$	$2 \times 10^{-7}$	$4 \times 10^{-7}$
	Sr 91	5	$4 \times 10^{-7}$	$2 \times 10^{-7}$	$2 \times 10^{-7}$	$7 \times 10^{-7}$
		1	$2 \times 10^{-7}$	$1 \times 10^{-7}$	$9 \times 10^{-8}$	$5 \times 10^{-7}$
	Sr 92	5	$4 \times 10^{-7}$	$2 \times 10^{-7}$	$2 \times 10^{-7}$	$7 \times 10^{-7}$
Sulfur (16)		1	$2 \times 10^{-7}$	$2 \times 10^{-7}$	$1 \times 10^{-7}$	$6 \times 10^{-7}$
	S 35	5	$2 \times 10^{-7}$	$2 \times 10^{-7}$	$9 \times 10^{-8}$	$6 \times 10^{-7}$
		1	$2 \times 10^{-7}$	$8 \times 10^{-8}$	$9 \times 10^{-8}$	$2 \times 10^{-6}$
	Ta 182	5	$4 \times 10^{-6}$	$1 \times 10^{-7}$	$1 \times 10^{-7}$	$4 \times 10^{-7}$
		1	$2 \times 10^{-6}$	$1 \times 10^{-7}$	$7 \times 10^{-8}$	$4 \times 10^{-7}$

# PART 20 • STANDARDS FOR PROTECTION AGAINST RADIATION

## APPENDIX B

Concentrations in Air and Water Above Natural Background—Continued  
(See notes at end of appendix)

Element (atomic number)	Isotope	S	Table I		Table II	
			Column 1	Column 2	Column 1	Column 2
			Air $+ \{ \mu\text{Ci/ml} \}$	Water $(\mu\text{Ci/ml})$	Air $(\mu\text{Ci/ml})$	Water $(\mu\text{Ci/ml})$
Technetium (43)	Tc 94m	5	$8 \times 10^{-3}$	$4 \times 10^{-1}$	$3 \times 10^{-2}$	$1 \times 10^{-1}$
	Tc 94	1	$2 \times 10^{-3}$	$2 \times 10^{-1}$	$1 \times 10^{-2}$	$1 \times 10^{-1}$
	Tc 96	5	$6 \times 10^{-3}$	$2 \times 10^{-1}$	$2 \times 10^{-2}$	$1 \times 10^{-1}$
	Tc 96	1	$2 \times 10^{-3}$	$1 \times 10^{-1}$	$8 \times 10^{-3}$	$5 \times 10^{-1}$
	Tc 97m	5	$2 \times 10^{-3}$	$1 \times 10^{-1}$	$8 \times 10^{-3}$	$4 \times 10^{-1}$
	Tc 97	1	$2 \times 10^{-3}$	$5 \times 10^{-2}$	$5 \times 10^{-3}$	$2 \times 10^{-1}$
	Tc 97	5	$1 \times 10^{-3}$	$5 \times 10^{-2}$	$4 \times 10^{-3}$	$2 \times 10^{-1}$
	Tc 97	1	$2 \times 10^{-3}$	$2 \times 10^{-2}$	$1 \times 10^{-3}$	$8 \times 10^{-2}$
	Tc 99m	5	$4 \times 10^{-3}$	$2 \times 10^{-1}$	$1 \times 10^{-2}$	$6 \times 10^{-1}$
	Tc 99	1	$1 \times 10^{-3}$	$8 \times 10^{-2}$	$5 \times 10^{-3}$	$3 \times 10^{-1}$
Tellurium (52)	Tc 99	5	$2 \times 10^{-3}$	$1 \times 10^{-1}$	$7 \times 10^{-3}$	$2 \times 10^{-1}$
	Tc 99	1	$6 \times 10^{-3}$	$5 \times 10^{-2}$	$2 \times 10^{-3}$	$2 \times 10^{-1}$
	Te 125m	5	$4 \times 10^{-3}$	$5 \times 10^{-2}$	$1 \times 10^{-3}$	$2 \times 10^{-1}$
	Te 125m	1	$1 \times 10^{-3}$	$2 \times 10^{-2}$	$4 \times 10^{-3}$	$1 \times 10^{-1}$
	Te 127m	5	$1 \times 10^{-3}$	$2 \times 10^{-2}$	$5 \times 10^{-3}$	$6 \times 10^{-2}$
	Te 127	1	$4 \times 10^{-3}$	$2 \times 10^{-2}$	$1 \times 10^{-3}$	$5 \times 10^{-2}$
	Te 127	5	$2 \times 10^{-3}$	$8 \times 10^{-2}$	$6 \times 10^{-3}$	$3 \times 10^{-1}$
	Te 127	1	$9 \times 10^{-3}$	$2 \times 10^{-2}$	$2 \times 10^{-3}$	$2 \times 10^{-1}$
	Te 129m	5	$8 \times 10^{-3}$	$1 \times 10^{-2}$	$2 \times 10^{-3}$	$2 \times 10^{-1}$
	Te 129	1	$2 \times 10^{-3}$	$6 \times 10^{-2}$	$1 \times 10^{-3}$	$2 \times 10^{-1}$
Terbium (65)	Te 129	5	$5 \times 10^{-3}$	$2 \times 10^{-2}$	$2 \times 10^{-3}$	$8 \times 10^{-2}$
	Te 129	1	$4 \times 10^{-3}$	$2 \times 10^{-2}$	$1 \times 10^{-3}$	$8 \times 10^{-2}$
	Te 131m	5	$4 \times 10^{-3}$	$2 \times 10^{-2}$	$1 \times 10^{-3}$	$6 \times 10^{-2}$
	Te 131m	1	$2 \times 10^{-3}$	$1 \times 10^{-2}$	$6 \times 10^{-3}$	$4 \times 10^{-2}$
	Te 132	5	$2 \times 10^{-3}$	$9 \times 10^{-2}$	$7 \times 10^{-3}$	$2 \times 10^{-1}$
	Te 132	1	$1 \times 10^{-3}$	$6 \times 10^{-2}$	$4 \times 10^{-3}$	$2 \times 10^{-1}$
	Tb 140	5	$1 \times 10^{-3}$	$1 \times 10^{-2}$	$2 \times 10^{-3}$	$4 \times 10^{-2}$
	Tb 140	1	$2 \times 10^{-3}$	$1 \times 10^{-2}$	$1 \times 10^{-3}$	$4 \times 10^{-2}$
	Ti 200	5	$2 \times 10^{-3}$	$1 \times 10^{-2}$	$9 \times 10^{-3}$	$4 \times 10^{-2}$
	Ti 200	1	$1 \times 10^{-3}$	$7 \times 10^{-2}$	$4 \times 10^{-3}$	$2 \times 10^{-1}$
Thallium (81)	Ti 201	5	$2 \times 10^{-3}$	$9 \times 10^{-2}$	$7 \times 10^{-3}$	$3 \times 10^{-1}$
	Ti 201	1	$9 \times 10^{-3}$	$5 \times 10^{-2}$	$3 \times 10^{-3}$	$2 \times 10^{-1}$
	Ti 202	5	$8 \times 10^{-3}$	$4 \times 10^{-2}$	$3 \times 10^{-3}$	$1 \times 10^{-1}$
	Ti 202	1	$2 \times 10^{-3}$	$2 \times 10^{-2}$	$8 \times 10^{-3}$	$7 \times 10^{-2}$
	Ti 204	5	$6 \times 10^{-3}$	$2 \times 10^{-2}$	$2 \times 10^{-3}$	$1 \times 10^{-1}$
	Ti 204	1	$3 \times 10^{-3}$	$2 \times 10^{-2}$	$9 \times 10^{-3}$	$6 \times 10^{-2}$
	Th 227	5	$3 \times 10^{-3}$	$5 \times 10^{-2}$	$1 \times 10^{-3}$	$2 \times 10^{-1}$
	Th 227	1	$2 \times 10^{-3}$	$8 \times 10^{-2}$	$6 \times 10^{-3}$	$2 \times 10^{-1}$
	Th 228	5	$9 \times 10^{-3}$	$2 \times 10^{-2}$	$3 \times 10^{-3}$	$7 \times 10^{-2}$
	Th 228	1	$6 \times 10^{-3}$	$4 \times 10^{-2}$	$2 \times 10^{-3}$	$1 \times 10^{-1}$
Thorium (90)	Th 230	5	$2 \times 10^{-3}$	$5 \times 10^{-2}$	$8 \times 10^{-3}$	$2 \times 10^{-1}$
	Th 230	1	$1 \times 10^{-3}$	$9 \times 10^{-2}$	$3 \times 10^{-3}$	$2 \times 10^{-1}$
	Th 231	5	$1 \times 10^{-3}$	$7 \times 10^{-2}$	$5 \times 10^{-3}$	$2 \times 10^{-1}$
	Th 231	1	$1 \times 10^{-3}$	$7 \times 10^{-2}$	$4 \times 10^{-3}$	$2 \times 10^{-1}$
	Th 232	5	$3 \times 10^{-3}$	$5 \times 10^{-2}$	$1 \times 10^{-3}$	$2 \times 10^{-1}$
	Th 232	1	$3 \times 10^{-3}$	$1 \times 10^{-2}$	$1 \times 10^{-3}$	$4 \times 10^{-2}$
	Th natural	5	$6 \times 10^{-3}$	$6 \times 10^{-2}$	$2 \times 10^{-3}$	$2 \times 10^{-1}$
	Th natural	1	$6 \times 10^{-3}$	$6 \times 10^{-2}$	$2 \times 10^{-3}$	$2 \times 10^{-1}$
	Th natural	5	$6 \times 10^{-3}$	$6 \times 10^{-2}$	$2 \times 10^{-3}$	$2 \times 10^{-1}$
	Th natural	1	$6 \times 10^{-3}$	$6 \times 10^{-2}$	$2 \times 10^{-3}$	$2 \times 10^{-1}$

# PART 20 • STANDARDS FOR PROTECTION AGAINST RADIATION

## APPENDIX B

### Concentrations in Air and Water Above Natural Background—Continued

[See notes at end of appendix.]

Element (atomic number)	Isotope		Table I		Table II	
			Column 1	Column 2	Column 1	Column 2
			Air † (μCi/ml)(μCi/ml)		Air † (μCi/ml)(μCi/ml)	
Thorium (90)	Th 234	S	$6 \times 10^{-7}$	$5 \times 10^{-4}$	$2 \times 10^{-7}$	$2 \times 10^{-7}$
	Th 230	I	$3 \times 10^{-8}$	$5 \times 10^{-4}$	$1 \times 10^{-8}$	$2 \times 10^{-7}$
Thallium (81)	Tm 170	S	$4 \times 10^{-8}$	$1 \times 10^{-3}$	$1 \times 10^{-8}$	$5 \times 10^{-7}$
	Tm 171	S	$2 \times 10^{-7}$	$1 \times 10^{-3}$	$1 \times 10^{-7}$	$2 \times 10^{-7}$
Tin (50)	Sn 113	S	$1 \times 10^{-7}$	$1 \times 10^{-3}$	$4 \times 10^{-8}$	$5 \times 10^{-7}$
	Sn 115	I	$2 \times 10^{-7}$	$2 \times 10^{-3}$	$1 \times 10^{-7}$	$9 \times 10^{-7}$
Tungsten (Wolfram) (74)	W 181	S	$5 \times 10^{-8}$	$2 \times 10^{-3}$	$2 \times 10^{-8}$	$2 \times 10^{-7}$
	W 182	I	$1 \times 10^{-7}$	$5 \times 10^{-4}$	$4 \times 10^{-8}$	$2 \times 10^{-7}$
	W 183	S	$6 \times 10^{-7}$	$1 \times 10^{-3}$	$3 \times 10^{-7}$	$4 \times 10^{-7}$
	W 187	S	$1 \times 10^{-7}$	$4 \times 10^{-3}$	$1 \times 10^{-7}$	$1 \times 10^{-7}$
Uranium (92)	U 230	S	$4 \times 10^{-7}$	$2 \times 10^{-3}$	$2 \times 10^{-7}$	$7 \times 10^{-7}$
	U 232	S	$3 \times 10^{-10}$	$2 \times 10^{-3}$	$1 \times 10^{-11}$	$6 \times 10^{-7}$
	U 233	I	$1 \times 10^{-10}$	$1 \times 10^{-3}$	$4 \times 10^{-12}$	$5 \times 10^{-7}$
	U 235	S	$1 \times 10^{-10}$	$8 \times 10^{-4}$	$3 \times 10^{-12}$	$2 \times 10^{-7}$
	U 238	S	$3 \times 10^{-11}$	$8 \times 10^{-4}$	$9 \times 10^{-13}$	$2 \times 10^{-7}$
	U 238	I	$3 \times 10^{-11}$	$9 \times 10^{-4}$	$2 \times 10^{-11}$	$3 \times 10^{-7}$
	U 234	S <sup>4</sup>	$1 \times 10^{-10}$	$9 \times 10^{-4}$	$3 \times 10^{-11}$	$3 \times 10^{-7}$
	U 235	S <sup>4</sup>	$6 \times 10^{-10}$	$9 \times 10^{-4}$	$4 \times 10^{-12}$	$2 \times 10^{-7}$
	U 236	S <sup>4</sup>	$1 \times 10^{-10}$	$8 \times 10^{-4}$	$2 \times 10^{-11}$	$3 \times 10^{-7}$
	U 236	I	$1 \times 10^{-10}$	$8 \times 10^{-4}$	$4 \times 10^{-12}$	$3 \times 10^{-7}$
	U 238	S <sup>4</sup>	$6 \times 10^{-10}$	$1 \times 10^{-3}$	$2 \times 10^{-11}$	$4 \times 10^{-7}$
	U 238	I	$1 \times 10^{-10}$	$1 \times 10^{-3}$	$4 \times 10^{-12}$	$3 \times 10^{-7}$
	U 240	S	$7 \times 10^{-11}$	$1 \times 10^{-3}$	$3 \times 10^{-12}$	$4 \times 10^{-7}$
	U 240	I	$1 \times 10^{-10}$	$1 \times 10^{-3}$	$5 \times 10^{-12}$	$4 \times 10^{-7}$
	U-natural	S <sup>4</sup>	$2 \times 10^{-7}$	$1 \times 10^{-3}$	$8 \times 10^{-8}$	$3 \times 10^{-7}$
	U-natural	I	$1 \times 10^{-10}$	$1 \times 10^{-3}$	$6 \times 10^{-12}$	$3 \times 10^{-7}$
Vanadium (23)	V 48	S	$1 \times 10^{-10}$	$1 \times 10^{-3}$	$5 \times 10^{-12}$	$3 \times 10^{-7}$
	V 48	I	$1 \times 10^{-10}$	$1 \times 10^{-3}$	$5 \times 10^{-12}$	$3 \times 10^{-7}$
Xenon (54)	Xe 121m	Sub	$2 \times 10^{-7}$	$9 \times 10^{-4}$	$4 \times 10^{-8}$	$2 \times 10^{-7}$
	Xe 123	Sub	$6 \times 10^{-8}$	$8 \times 10^{-4}$	$2 \times 10^{-8}$	$3 \times 10^{-7}$
	Xe 133m	Sub	$1 \times 10^{-7}$		$4 \times 10^{-7}$	$1 \times 10^{-7}$
	Xe 135	Sub	$1 \times 10^{-7}$		$3 \times 10^{-7}$	$1 \times 10^{-7}$
Ytterbium (70)	Yb 173	S	$4 \times 10^{-8}$	$1 \times 10^{-3}$	$1 \times 10^{-7}$	$1 \times 10^{-7}$
	Yb 173	I	$7 \times 10^{-7}$	$3 \times 10^{-3}$	$2 \times 10^{-7}$	$1 \times 10^{-7}$
Yttrium (39)	Y 90	S	$6 \times 10^{-7}$	$3 \times 10^{-3}$	$2 \times 10^{-7}$	$1 \times 10^{-7}$
	Y 91m	I	$1 \times 10^{-7}$	$6 \times 10^{-4}$	$4 \times 10^{-8}$	$2 \times 10^{-7}$
	Y 91m	S	$1 \times 10^{-7}$	$6 \times 10^{-4}$	$3 \times 10^{-8}$	$2 \times 10^{-7}$
	Y 91	S	$2 \times 10^{-7}$	$1 \times 10^{-3}$	$6 \times 10^{-7}$	$3 \times 10^{-7}$
	Y 91	I	$3 \times 10^{-7}$	$1 \times 10^{-3}$	$6 \times 10^{-7}$	$3 \times 10^{-7}$
	Y 91	S	$4 \times 10^{-7}$	$8 \times 10^{-4}$	$1 \times 10^{-7}$	$3 \times 10^{-7}$
	Y 92	I	$3 \times 10^{-7}$	$8 \times 10^{-4}$	$1 \times 10^{-7}$	$3 \times 10^{-7}$
	Y 92	S	$4 \times 10^{-7}$	$2 \times 10^{-3}$	$1 \times 10^{-7}$	$6 \times 10^{-7}$
	Y 93	I	$3 \times 10^{-7}$	$2 \times 10^{-3}$	$1 \times 10^{-7}$	$6 \times 10^{-7}$
	Y 93	S	$2 \times 10^{-7}$	$5 \times 10^{-4}$	$6 \times 10^{-7}$	$3 \times 10^{-7}$
	Y 93	I	$1 \times 10^{-7}$	$8 \times 10^{-4}$	$5 \times 10^{-7}$	$3 \times 10^{-7}$

# PART 20 • STANDARDS FOR PROTECTION AGAINST RADIATION

## APPENDIX 3

Concentrations in Air and Water Above Natural Background—Continued

Element (atomic number)	Isotope <sup>1</sup>		Table I		Table II	
			Column 1	Column 2	Column 1	Column 2
			Air ( $\mu\text{Ci/ml}$ )	Water ( $\mu\text{Ci/ml}$ )	Air ( $\mu\text{Ci/ml}$ )	Water ( $\mu\text{Ci/ml}$ )
Zinc (30)	Zn 65	S	$1 \times 10^{-7}$	$3 \times 10^{-3}$	$4 \times 10^{-8}$	$1 \times 10^{-4}$
	I		$4 \times 10^{-8}$	$5 \times 10^{-3}$	$2 \times 10^{-8}$	$2 \times 10^{-4}$
	Zn 69m	S	$4 \times 10^{-7}$	$2 \times 10^{-3}$	$1 \times 10^{-8}$	$7 \times 10^{-3}$
	I		$3 \times 10^{-7}$	$2 \times 10^{-3}$	$1 \times 10^{-8}$	$4 \times 10^{-3}$
	Zn 69	S	$7 \times 10^{-8}$	$5 \times 10^{-3}$	$2 \times 10^{-8}$	$2 \times 10^{-3}$
Zirconium (40)	I		$9 \times 10^{-8}$	$5 \times 10^{-3}$	$3 \times 10^{-8}$	$2 \times 10^{-3}$
	Zr 93	S	$1 \times 10^{-7}$	$2 \times 10^{-3}$	$4 \times 10^{-8}$	$8 \times 10^{-4}$
	I		$3 \times 10^{-7}$	$2 \times 10^{-3}$	$1 \times 10^{-8}$	$8 \times 10^{-4}$
	Zr 95	S	$1 \times 10^{-7}$	$2 \times 10^{-3}$	$4 \times 10^{-8}$	$4 \times 10^{-4}$
	I		$3 \times 10^{-8}$	$2 \times 10^{-3}$	$1 \times 10^{-8}$	$4 \times 10^{-4}$
	Zr 97	S	$1 \times 10^{-7}$	$5 \times 10^{-4}$	$4 \times 10^{-8}$	$2 \times 10^{-4}$
	I		$9 \times 10^{-8}$	$5 \times 10^{-4}$	$3 \times 10^{-8}$	$2 \times 10^{-4}$
	Sub		$1 \times 10^{-8}$		$3 \times 10^{-8}$	
Any single radionuclide not listed above with decay mode other than alpha emission or spontaneous fission and with radioactive half-life less than 2 hours.			$3 \times 10^{-8}$	$9 \times 10^{-7}$	$1 \times 10^{-10}$	$3 \times 10^{-6}$
Any single radionuclide not listed above with decay mode other than alpha emission or spontaneous fission and with radioactive half-life greater than 2 hours.			$6 \times 10^{-12}$	$4 \times 10^{-7}$	$2 \times 10^{-14}$	$3 \times 10^{-6}$
Any single radionuclide not listed above, which decays by alpha emission or spontaneous fission.						

<sup>1</sup> Soluble (S); insoluble (I).

<sup>2</sup> "Sub" means that values given are for submersion in a semapherical infinite cloud of airborne material.

<sup>3</sup> These radon concentrations are appropriate for protection from radon-222 combined with its short-lived daughters. Alternatively, the value in Table I may be replaced by one-third ( $\frac{1}{3}$ ) "working level." (A "working level" is defined as any combination of short-lived radon-222 daughters, polonium-218, lead-214, bismuth-214 and polonium-214, in one liter of air, without regard to the degree of equilibrium, that will result in the ultimate emission of  $1.3 \times 10^5$  MeV of alpha particle energy.) The Table II value may be replaced by one-thirtieth ( $\frac{1}{30}$ ) of a "working level." The limit on radon-222 concentrations in restricted areas may be based on an annual average.

14. For soluble mixtures of U-238, U-234 and U-235 in air chemical toxicity may be the limiting factor. If the percent by weight (enrichment) of U-235 is less than 5, the concentration value for a 40-hour workweek, Table I, is 0.3 milligrams uranium per cubic meter of air average. For any enrichment, the product of the average concentration and time of exposure during a 40-hour workweek shall not exceed  $8 \times 10^{-4}$  SA  $\mu\text{Ci-hr/ml}$ , where SA is the specific activity of the uranium inhaled. The concentration value for Table II is 0.007 milligrams uranium per cubic meter of air. The specific activity for natural uranium is  $6.77 \times 10^{-4}$  curies per gram U. The specific activity for other mixtures of U-238, U-235 and U-234, if not known, shall be:  
 $\text{SA} = 5.8 \times 10^{-4}$  curies/gram U  $\frac{\text{U-depleted}}{\text{U-235}}$   
 $\text{SA} = (0.4 + 0.38 \text{ E} + 0.0054 \text{ E}^2) \times 10^{-4}$  E 20.72  
 where E is the percentage by weight of U-235 expressed as percent.

\* Amended 37 FR 23319.

\*\* Amended 39 FR 23990; footnote redesignated 40 FR 50704.

\*\*\* Amended 40 FR 50704.

† Amended 38 FR 29314.

‡ Amended 39 FR 25463; redesignated 40 FR 50704.



## NOTE TO APPENDIX B

EXAMPLE: If radionuclides A, B, and C are present in concentrations  $C_A$ ,  $C_B$ , and  $C_C$ , and if the applicable MPC's are  $MPC_A$ ,  $MPC_B$ , and  $MPC_C$  respectively, then the concentrations shall be limited so that the following relationship exists:

$$\frac{C_A}{MPC_A} + \frac{C_B}{MPC_B} + \frac{C_C}{MPC_C} \leq 1$$

d. For purposes of Table II, Col. 2— $3 \times 10^{-4}$

b. If the identity of each radionuclide in the mixture is not known, but it is known that certain radionuclides specified in Appendix "B" are not present in the mixture, the concentration limit for the mixture is the lowest concentration limit specified in Appendix "B" for any radionuclide which is not known to be absent from the mixture; or

NO. FR. 158.14.
$$(i.e. \frac{G_1}{MFC_1} + \frac{G_2}{MFC_2} + \dots \leq M).$$

# PART 20 • STANDARDS FOR PROTECTION AGAINST RADIATION

## APPENDIX C

Material	Microcuries
Americium-241	.01
Antimony-122	100
Antimony-134	10
Antimony-138	10
Arsenic-73	100
Arsenic-74	10
Arsenic-76	10
Arsenic-77	100
Barium-131	10
Barium-133	10
Barium-140	10
Bismuth-210	1
Bromine-82	10
Cadmium-109	10
Cadmium-115m	10
Cadmium-116	100
Calcium-45	10
Calcium-47	10
Carbon-14	100
Cerium-141	100
Cerium-143	100
Cerium-144	1
Cesium-131	1,000
Cesium-134m	100
Cesium-134	1
Cesium-135	10
Cesium-136	10
Cesium-137	10
Chlorine-36	10
Chlorine-38	10
Chromium-51	1,000
Cobalt-58m	10
Cobalt-58	10
Cobalt-60	1
Copper-64	100
Dysprosium-165	10
Dysprosium-166	100
Erbium-169	100
Erbium-171	100
Europium-152 9.2 h	100
Europium-152 13 yr	1
Europium-154	1
Europium-155	10
Fluorine-18	1,000
Gadolinium-153	10
Gadolinium-159	100
Gallium-72	10
Germanium-71	100
Gold-198	100
Gold-199	100
Hafnium-181	10
Holmium-166	100
Hydrogen-3	1,000
Indium-113m	100
Indium-114m	10
Indium-115m	100
Indium-115	10
Iodine-125	1
Iodine-126	1
Iodine-129	.01
Iodine-131	1
Iodine-132	10
Iodine-133	1
Iodine-134	10
Iodine-135	10
Iridium-192	10
Iridium-194	100
Iron-55	100
Iron-59	10
Krypton-85	100
Krypton-87	10
Lanthanum-140	10
Lutetium-177	100
Manganese-52	10
Manganese-54	10
Manganese-56	10
Mercury-197m	100
Mercury-197	100
Mercury-203	10
Molybdenum-99	100
Neodymium-147	100
Neodymium-149	100
Nickel-50	100
Nickel-63	10
Nickel-65	100
Niobium-93m	10
Niobium-95	10
Niobium-97	10
Osmium-185	10

Material	Microcuries
Osmium-191m <sup>1</sup>	100
Osmium-191	100
Osmium-195	100
Palladium-103	100
Palladium-106	100
Phosphorus-32	10
Platinum-191	100
Platinum-196m	100
Platinum-198	100
Platinum-197m	100
Platinum-197	100
Plutonium-239	100
Polonium-210	.01
Potassium-42	10
Praseodymium-143	100
Praseodymium-145	100
Promethium-147	10
Promethium-149	10
Radium-226	.01
Rhenium-186	100
Rhenium-188	100
Rhodium-103m	100
Rhodium-106	100
Rubidium-86	10
Rubidium-87	10
Ruthenium-97	100
Ruthenium-106	10
Ruthenium-108	10
Ruthenium-109	1
Samarium-151	10
Samarium-153	100
Scandium-46	10
Scandium-47	100
Scandium-48	10
Selenium-75	10
Silicon-31	100
Silver-106	10
Silver-110m	1
Silver-111	100
Sodium-24	10
Strontium-85	10
Strontium-89	1
Strontium-90	.01
Strontium-91	10
Strontium-92	10
Sulphur-35	100
Tantalum-182	10
Technetium-96	10
Technetium-97m	100
Technetium-97	100
Technetium-99m	100
Technetium-99	10
Tellurium-125m	10
Tellurium-127m	10
Tellurium-127	100
Tellurium-129m	10
Tellurium-129	100
Tellurium-131m	10
Tellurium-132	10
Terbium-160	10
Thallium-200	100
Thallium-201	100
Thallium-202	100
Thallium-204	10
Thorium (natural) <sup>1</sup>	100
Thulium-170	10
Thulium-171	10
Tin-113	10
Tin-125	10
Tungsten-181	10
Tungsten-185	10
Tungsten-187	100
Uranium (natural) <sup>1</sup>	100
Uranium-233	.01
Uranium-234 Uranium-235	.01
Vanadium-48	10
Xenon-131m	1,000
Xenon-133	100
Xenon-135	100
Ytterbium-175	100
Yttrium-90	10
Yttrium-91	10
Yttrium-92	100
Yttrium-93	100
Zinc-65	10
Zinc-69m	100
Zinc-69	1,000
Zirconium-93	10
Zirconium-95	10
Zirconium-97	10

Any alpha emitting radionuclide not listed above or mixtures of alpha emitters of unknown composition .01

Any radionuclide other than alpha emitting radionuclides not listed above or mixtures of beta emitters of unknown composition... 1

Note.—For purposes of § 20.303, where there is involved a combination of isotopes in known amounts, the limit for the combination should be derived as follows. Determine, for each isotope in the combination, the ratio between the quantity present in the combination and the limit otherwise established for the specific isotope when not in combination. The sum of such ratios for all the isotopes in the combination may not exceed "1" (i.e., "unity").

<sup>1</sup>Based on alpha disintegration rate of Th-232, Th-230 and their daughter products.

<sup>2</sup>Based on alpha disintegration rate of U-238, U-234, and U-235.

\* Amended 36 F.R. 16898.

\*\* Amended 39 F.R. 23490.

CONTROL NO. 7 9281

# PART 20 • STANDARDS FOR PROTECTION AGAINST RADIATION

## APPENDIX D.—UNITED STATES NUCLEAR REGULATORY COMMISSION REGIONAL OFFICES

	Address	Telephone (24 hrs)
Region I: Connecticut, Delaware, District of Columbia, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont.	USNRC, 631 Park Ave., King of Prussia, PA 19406	(215) 337-8000 (FTS) 486-1000.
Region II: Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, Puerto Rico, South Carolina, Tennessee, Virginia, Virgin Islands, and West Virginia.	USNRC, 101 Marietta Street, Suite 3100, Atlanta, GA 30303	(404) 221-4503 (FTS) 242-4503.
Region III: Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Ohio, and Wisconsin.	USNRC, 799 Roosevelt Road, Glen Ellyn, IL 60137	(312) 790-5500 (FTS) 386-5500.
Region IV: Arkansas, Colorado, Idaho, Kansas, Louisiana, Montana, Nebraska, New Mexico, North Dakota, Oklahoma, South Dakota, Texas, Utah, and Wyoming.	USNRC, 611 Ryan Plaza Drive, Suite 1000, Arlington, TX 76011	(817) 860-8100 (FTS) 726-8100.
Region IV Field Office	USNRC, Region IV Uranium Recovery Field Office, 730 Simms Street, P.O. Box 25325, Denver, CO 80225	(303) 234-7232 (FTS) 234-7232.
Region V: Alaska, Arizona, California, Hawaii, Nevada, Oregon, Washington, and U.S. territories and possessions in the Pacific.	USNRC, 1450 Mare Lane, Suite 210, Walnut Creek, CA 94596	(415) 943-3700 (FTS) 463-3700.

# REGULATORY GUIDE

OFFICE OF STANDARDS DEVELOPMENT

## REGULATORY GUIDE 8.10

## OPERATING PHILOSOPHY FOR MAINTAINING OCCUPATIONAL RADIATION EXPOSURES AS LOW AS IS REASONABLY ACHIEVABLE

### A. INTRODUCTION

Paragraph 20.1(c) of 10 CFR Part 20, "Standards for Protection Against Radiation," states, in part, that licensees should make every reasonable effort to maintain radiation exposures as far below the limits specified in that part as practicable. This guide describes to licensees a general operating philosophy acceptable to the NRC staff as a necessary basis for a program of maintaining occupational exposures to radiation as low as is reasonably achievable.

Both this guide and Regulatory Guide 8.8, "Information Relevant to Maintaining Occupational Radiation Exposure as Low as is Reasonably Achievable (Nuclear Power Reactors)," deal with the concept of "as low as is reasonably achievable" occupational exposures to radiation. The main difference between the two guides, aside from the fact that Regulatory Guide 8.8 applies only to nuclear power reactors and this guide applies to all specific licensees, is that Regulatory Guide 8.8 is addressed to applicants for a license and tells them what information relevant to "as low as is reasonably achievable" should be included in their license applications. This guide, on the other hand, describes an operating philosophy that the NRC staff believes all specific licensees should follow to keep occupational exposures to radiation as low as is reasonably achievable.

### B. DISCUSSION

Even though current occupational exposure limits provide a very low risk of injury, it is prudent to avoid unnecessary exposure to radiation. The objective is thus to reduce occupational exposures as far below the specified limits as is reasonably achievable by means of good radiation protection planning and practice, as well as by management commitment to policies that foster vigilance against departures from good practice.

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

### C. REGULATORY POSITION

Two basic conditions are considered necessary in any program for keeping occupational exposures as far below the specified limits as is reasonably achievable. The management of the licensed facility should be committed to maintaining exposures as low as is reasonably achievable, and the personnel responsible for radiation protection should be continually vigilant for means to reduce exposures.

#### 1. Management Commitment

The commitment made by licensee management to minimize exposures should provide clearly defined radiation protection responsibilities and an environment in which the radiation protection staff can do its job properly. There are several aspects to this commitment:

a. Plant personnel should be made aware of management's commitment to keep occupational exposures as low as is reasonably achievable. The commitment should appear in policy statements, instructions to personnel, and similar documents. As a minimum, workers should be sufficiently familiar with this commitment that they can explain what the management commitment is, what "as low as is reasonably achievable exposure to radiation" means, why it is recommended, and how they have been advised to implement it on their jobs.

#### USNRC REGULATORY GUIDES

Regulatory Guides are issued to describe and make available to the public methods acceptable to the NRC staff of implementing specific parts of the Commission's regulations, to delineate techniques used by the staff in evaluating specific problems or postulated accidents, or to provide guidance to applicants. Regulatory Guides are not substitutes for regulations, and compliance with them is not required. Methods and solutions different from those set out in the guides will be acceptable if they provide a basis for the findings requisite to the issuance or continuance of a permit or license by the Commission.

Comments and suggestions for improvements in these guides are encouraged at all times, and guides will be revised as appropriate to accommodate comments and to reflect new information or experience. However, comments on this guide, if received within about two months after its issuance, will be particularly useful in evaluating the need for an early revision.

Comments should be sent to the Secretary of the Commission, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, Attention: Documenting and Service Section.

The guides are issued in the following ten broad divisions:

- |                                   |                        |
|-----------------------------------|------------------------|
| 1. Power Reactors                 | 5. Products            |
| 2. Research and Test Reactors     | 6. Transportation      |
| 3. Fuels and Materials Facilities | 7. Occupational Health |
| 4. Environmental and Siteing      | 8. Amendment Review    |
| 5. Materials and Plant Protection | 9. General             |

Copies of published guides may be obtained by written request indicating the divisions desired to the U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, Attention: Director, Office of Standards Development.

CONTROL NO. 7 928 1



b. Management should periodically perform a formal audit to determine how exposures might be lowered. This should include reviews of operating procedures and past exposure records, plant inspections, and consultations with the radiation protection staff or outside consultants. As a minimum, management should be able to discuss which operating procedures were reviewed, in which locations most exposures are being received, what groups of workers are receiving the highest exposures, what discussions they have had with the radiation protection staff or outside consultants, and what steps they have taken to reduce exposures.

c. The management should ensure that there is a well-supervised radiation protection capability with well-defined responsibilities. The qualifications for the Radiation Protection Manager for a nuclear power reactor facility are presented in Regulatory Guides 1.8 and 8.8. Applicants submitting applications for any specific license other than a nuclear power reactor license should select and state the qualifications for the lead individual who will be responsible for implementing the radiation protection program for the facility, i.e., the Radiation Safety Officer (RSO).<sup>1</sup> The qualifications selected should be commensurate with the potential problems anticipated to be encountered in a facility of the type subject to the license.

d. The management should see that plant workers receive sufficient training. Section 19.12 of 10 CFR Part 19 requires instruction of personnel on radiation protection. The radiation worker should understand how radiation protection relates to his job and should be tested on this understanding at least once per year. He should have frequent opportunities to discuss radiation safety with the radiation protection staff whenever the need arises. Management should be committed to a review of radiation protection at least once every three years. Training should be sufficient to ensure that the workers can correctly answer questions on radiation protection as it relates to their jobs.

e. The RSO should be given sufficient authority to enforce safe plant operation. The RSO should have the authority to prevent unsafe practices and to communicate promptly with an appropriate level of management about halting an operation he deems unsafe. Operating procedures related to radiation safety should be reviewed and approved by radiation protection personnel. This authority should be demonstrable by written policy statements.

f. Modifications to operating and maintenance procedures and to plant equipment and facilities should be made where they will substantially reduce exposures at a reasonable cost. The management should be able to

demonstrate that improvements have been sought, that modifications have been considered, and that they have been implemented where practicable. Where modifications have been considered but not implemented, the licensee should be prepared to describe the reasons for not implementing them.

## 2. Vigilance by the RSO and the Radiation Protection Staff

It should be the responsibility of the RSO and the radiation protection staff to conduct surveillance programs and investigations to ensure that occupational exposures are as far below the specified limits as is reasonably achievable. Additionally, they should be vigilant in searching out new and better ways to perform all radiation jobs with less exposure. There are several aspects to this responsibility.

a. The RSO and the radiation protection staff should know the origins of radiation exposures in the plant. They should know these by location, operation, and job category and should be aware of trends in exposures. Where radiation work permits are used, exposures received should be recorded on the permits. The RSO and the radiation protection staff should be able to describe which locations, operations, and jobs are associated with the highest exposures and why exposures are increasing or decreasing.

b. The RSO and the radiation protection staff should look for ways to reduce exposures. When unusual exposures have occurred, the radiation protection staff should direct and participate in an investigation of the circumstances of such exposures to determine the causes and take steps to reduce the likelihood of similar future occurrences. For each such occurrence, the RSO should be able to demonstrate that such an investigation has been carried out, that conclusions were reached as a result of the investigation, and that corrective action was taken, as appropriate.

The RSO and the radiation protection staff should periodically review operating procedures that may affect radiation safety and survey plant operations to identify situations in which exposures can be reduced. Indicated changes should be promptly implemented. Procedures for receiving and evaluating suggestions relating to radiation protection from employees should be established. Workers should be knowledgeable of the procedures for making suggestions on radiation protection.

c. Adequate equipment and supplies for radiation protection work should be provided. The RSO should be responsible for ensuring that proper equipment and supplies are available, are maintained in good working order, and are used properly. Written procedures for the use of the equipment should be available and followed.

<sup>1</sup> Lines indicate substantive changes from previous issue.

<sup>2</sup> The term "Radiation Safety Officer" is used by many licensees; other terms are equally acceptable.

#### D. IMPLEMENTATION

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

Except in those cases in which the applicant or licensee proposes an alternative method for complying

with the specified portions of the Commission's regulations, the methods described herein will be used in the evaluation of submittals in connection with applications for a specific license.

Regulatory Guides 1.8 and 8.8 address nuclear power reactor facilities specifically and will be used by the NRC staff in evaluating submittals in connection with licensing actions for nuclear power reactors.



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

JUN 13 1980

RECEIVED

JUN 23 1980

R.E. MEGRAW

TO ALL NRC MEDICAL LICENSEES

ALARA

Dear Licensee:

On September 28, 1979 we sent you a letter about an ALARA program to be implemented by December 4, 1979. We subsequently informed you that the implementation date was being delayed until March 4, 1980 in order to revise the model ALARA program to take into account many comments we received. Enclosed is a revised program which should be implemented by August 15, 1980. Additional time is being allowed so that licensees can make appropriate adjustments in their programs. During the past two months we have sought and considered the opinions and comments of many professionals in all areas involving the use of radiation in medicine. These discussions have led us to modify several program elements and to clarify others. The revised program reduces the administrative burden on the licensee while still meeting the original goal; to provide management a tool for maintaining occupational exposures ALARA and to provide NRC with a basis for inspecting ALARA programs.

The original program provided for establishment of an Action Level which was misinterpreted as a lowering of the maximum permissible dose limits. This was not, and is not, the intention of the program. The revised program applies the concept of "Investigational Levels" as defined in ICRP Report No. 26 "Recommendations of the Commission on Radiological Protection," January 17, 1977. The Investigational Levels in the revised program are not new dose limits but, as noted in the ICRP report, serve as check points above which the results are considered sufficiently important to justify further investigations. Investigational Levels are tools to be used by those in your institution responsible for the management of radiation safety programs. In determining compliance with regulations, NRC will be concerned with whether a review and/or investigation has been carried out rather than whether the Investigational Level has been exceeded.

There was concern on the part of some licensees that improved measurements would be required to comply with the program. Current methods of recording personnel exposures for purposes of compliance with 10 CFR 20, §20.101 are also adequate for use in determining the need for a review or investigation in accordance with the ALARA program.

CONTROL NO. 7 928 1

The new program has been revised to considerably reduce the paperwork burden. Actions to be taken under the revised ALARA program will be included in, or covered by, documentation already required to be maintained by licensees. Results of personnel monitoring are already recorded at least quarterly on Form NRC-5 or an equivalent form as required by 10 CFR 20.1401. Results of investigations you make when an Investigational Level is exceeded should be made part of the Radiation Safety Committee minutes, thus eliminating the need for a separate record. A private practice nuclear medicine licensee would need to maintain review or investigation records but since the majority of these licensees employ few staff requiring personnel monitoring this obligation should create no undue burden.

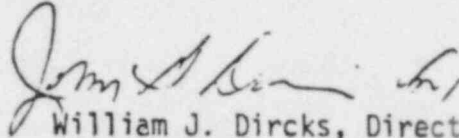
In the original program, reference was made to guidance provided by U.S. Nuclear Regulatory Guides 8.10 and 8.18. Some interpreted this as a commitment for strict adherence to all aspects of these guides. The guidance given in these documents should be reviewed to determine if the benefits, in terms of additional dose reductions, are justified by the cost of those reductions. Both guides are now used by the NRC licensing staff as part of the basis for evaluating license applications and radiation safety programs. NRC will continue to consider equivalent alternative methods of complying with the principles contained in the guides and with specified portions of the Commission's regulations. You should be aware that these are only two of many sources of information available to guide you in maintaining occupational radiation exposures at medical institutions ALARA. Another good reference source available from NRC is NUREG-0267, "Principles and Practices for Keeping Occupational Radiation Exposures At Medical Institutions As Low As Reasonably Achievable." The model program applies only to the radiation exposure of personnel arising in whole or in part from NRC licensed byproduct materials. Expanding the program to cover other radiation workers in your institution is an option available to you.

The revised model of an ALARA program is provided as an enclosure to this letter. Your institution should adopt this program or develop an equivalent alternative program for review by NRC. After August 15, 1980 you will submit your program when you submit your next renewal or significant amendment application. If necessary for clarification or emphasis, you are encouraged to add explanatory text to the model program. If accepted, your program will be incorporated as a condition of your NRC license. There is no need to submit your ALARA program to NRC until such time as you amend or renew your license. However, you should implement the program within your institution as soon as possible, if you have not already done so. Those licensees who have already submitted programs in accordance with the original model or an equivalent alternative program may either resubmit a revised program or maintain the program as proposed unless notified otherwise by NRC. NB



I would like to emphasize that the ALARA concept is not new and that most of the commitments in the enclosed formal program are already adhered to by those who maintain good radiation safety programs.

Sincerely,



William J. Dircks, Director  
Office of Nuclear Material Safety  
and Safeguards

Approved by GAO  
B-180225 (R0658)  
Expires 83-05-31

Model Program for Maintaining Occupational  
Radiation Exposures at Medical Institutions ALARA

\_\_\_\_\_  
(Licensee's Name)

\_\_\_\_\_  
(Date)

I. Management Commitment

- a. We, the management of this (medical facility, hospital, etc.) are committed to the program described in this paper for keeping exposures (individual and collective) as low as reasonably achievable (ALARA). In accord with this commitment, we hereby describe an administrative organization for radiation safety and will develop the necessary written policy, procedures and instructions to foster the ALARA concept within our institution. The organization will include a Radiation Safety Committee (RSC)<sup>1</sup> and a Radiation Safety Officer (RSO).
- b. We will perform a formal annual review of the radiation safety program including ALARA considerations. This shall include reviews of operating procedures and past exposure records, inspections, etc., and consultations with the radiation protection staff or outside consultants.
- c. Modification to operating and maintenance procedures and to equipment and facilities will be made where they will reduce exposures unless the cost, in our judgement, is considered to be unjustified. We will be able to demonstrate, if necessary, that improvements have been sought, that modifications have been considered, and that they have been implemented where reasonable. Where modifications have been recommended but not implemented, we will be prepared to describe the reasons for not implementing them.
- d. In addition to maintaining doses to individuals as far below the limits as is reasonably achievable, the sum of the doses received by all exposed individuals will also be maintained at the lowest practicable level. It would not be desirable, for example, to hold the highest doses to individuals to some fraction of the applicable limit if this involved exposing additional people and significantly increasing the sum of radiation doses received by all involved individuals.

<sup>1</sup> Private practice physician licenses do not include a RSC.

## II. Radiation Safety Committee (RSC)<sup>2</sup>

### a. Review of Proposed Users and Uses

1. The RSC will thoroughly review the qualifications of each applicant with respect to the types and quantities of materials and uses for which he has applied to assure that the applicant will be able to take appropriate measures to maintain exposure ALARA.
2. When considering a new use of byproduct material, the RSC will review the efforts of the applicant to maintain exposure ALARA. The user should have systematized procedures to ensure ALARA, and shall have incorporated the use of special equipment such as syringe shields, rubber gloves, etc., in his proposed use.
3. The RSC will ensure that the user justifies his procedures and that dose will be ALARA (individual and collective).

### b. Delegation of Authority

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

1. The RSC will delegate authority to the RSO for enforcement of the ALARA concept.
2. The RSC will support the RSO in those instances where it is necessary for the RSO to assert his authority. Where the RSO has been overruled, the Committee will record the basis for its action in the minutes of the Committee's quarterly meeting.

### c. Review of ALARA Program

1. The RSC will encourage all users to review current procedures and develop new procedures as appropriate to implement the ALARA concept.
2. The RSC will perform a quarterly review of occupational radiation exposure with particular attention to instances where Investigational Levels in Table I below are exceeded. The principle purpose of this review is to assess trends in occupational exposure as an index of the ALARA program quality and to decide if action is warranted when Investigational Levels are exceeded (see paragraph VI).<sup>3</sup>

---

<sup>2</sup>The RSO on private practice physician licenses will assume the responsibilities of the RSC under Section II

---

<sup>3</sup>The NRC has emphasized that the Investigational Levels in this program are not new dose limits but, as noted in ICRP Report 26, "Recommendations of the International Commission on Radiological Protection", serve as check points above which the results are considered sufficiently important to justify further investigations.

3. The RSC will evaluate our institution's overall efforts for maintaining exposures ALARA on an annual basis. This review will include the efforts of the RSO, authorized users, and workers as well as those of management.

### III. Radiation Safety Officer (RSO)

#### a. Annual and Quarterly Review

1. Annual review of the Radiation Safety Program. The RSO will perform an annual review of the Radiation Safety Program for adherence to ALARA concepts. Reviews of specific procedures may be conducted on a more frequent basis.
2. Quarterly review of Occupational Exposures. The RSO will review at least quarterly the external radiation exposures of authorized users and workers to determine that their exposures are ALARA in accordance with the provisions of paragraph VI of this program.
3. Quarterly review of records of Radiation Level Surveys. The RSO will review radiation levels in unrestricted and restricted areas to determine that they were at ALARA levels during the previous quarter.

#### b. Education Responsibilities for an ALARA Program

1. The RSO will schedule briefings and educational sessions to inform workers of ALARA program efforts.
2. The RSO will assure that authorized users, workers and ancillary personnel who may be exposed to radiation will be instructed in the ALARA philosophy and informed that management, the RSC and the RSO are committed to implementing the ALARA concept.

#### c. Cooperative Efforts for Development of ALARA Procedures

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

1. The RSO will be in close contact with all users and workers in order to develop ALARA procedures for working with radioactive materials.
2. The RSO will establish procedures for receiving and evaluating the suggestions of individual workers for improving health physics practices and encourage the use of those procedures.



d. Reviewing Instances of Deviation from Good ALARA Practices

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

IV. Authorized Users

a. New Procedures Involving Potential Radiation Exposures

1. The authorized user will consult with, and receive the approval of, the RSO and/or RSC during the planning stage before using radioactive materials for a new procedure.
2. The authorized user will evaluate all procedures before using radioactive materials to ensure that exposures will be kept ALARA. This may be enhanced through the application of trial runs.

b. Responsibility of the Authorized User to Those He Supervises

1. The authorized user will explain the ALARA concept and his commitment to maintain exposures ALARA to all of those he supervises.
2. The authorized user will ensure that those under his supervision who are subject to occupational radiation exposure are trained and educated in good health physics practices and in maintaining exposures ALARA.

V. Persons Who Receive Occupational Radiation Exposure

- a. The worker will be instructed in the ALARA concept and its relationship to his working procedures and work conditions.
- b. The worker will know what recourses are available if he feels that ALARA is not being promoted on the job.

VI. Establishment of Investigational Levels In Order to Monitor Individual Occupational External Radiation Exposures

This institution (or private practice) hereby establishes Investigational Levels for occupational external radiation exposure which, when exceeded, will initiate review or investigation by the Radiation Safety Committee and/or the Radiation Safety Officer. The Investigational Levels that we have adopted are listed in Table 1 below. These levels apply to the exposure of individual workers.

Table 1

Investigational Levels - (mrems per calendar quarter)		
	<u>LEVEL I</u>	<u>LEVEL II</u>
1. Whole body; head and trunk; active blood-forming organs; lens of eyes; or gonads	125	375
2. Hands and forearms; feet and ankles	1875	5625
3. Skin of whole body*	750	2250

\* Not normally applicable to nuclear medicine operations except those using significant quantities of beta emitting isotopes.

The Radiation Safety Officer will review and record on Form NRC-5, Current Occupational External Radiation Exposures, or an equivalent form (e.g. dosimeter processor's report), results of personnel monitoring, not less than once in any calendar quarter, as is required by 10 CFR 20, §20.401. The following actions will be taken at the Investigational Levels as stated in Table 1:

- a. Quarterly exposure of individuals to less than Investigational Level I.

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

- b. Personnel exposures equal to or greater than Investigational Level I, but less than Investigational Level II.

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

c. Exposure equal to or greater than Investigational Level II.

The RSO will investigate in a timely manner the cause(s) of all personnel exposures equaling or exceeding Investigational Level II and, if warranted, take action. A report of the investigation, actions taken, if any, and a copy of the individual's Form NRC-5 or its equivalent will be presented to the RSC at the first RSC meeting following completion of the investigation. The details of these reports will be recorded in the Committee minutes. Committee minutes will be sent to the management of this institution for review. The minutes, containing details of the investigation, will be made available to NRC inspectors for review at the time of the next inspection.

d. Re-establishment of an individual occupational worker's Investigational Level II Above That Listed In Table I.

In cases where a worker's or a group of worker's exposures need to exceed Investigational Level II, a new, higher Investigational Level II may be established on the basis that it is consistent with good ALARA practices for that individual or group. Justification for a new Investigational Level II will be documented.

The Radiation Safety Committee will review the justification for, and will approve, all revisions of Investigational Levels II. In such cases, when the exposure equals or exceeds the newly established Investigational Level II, those actions listed in paragraph c above will be followed.

VII. Signature of Certifying Official<sup>4</sup>

I hereby certify that this institution (or private practice), has implemented the ALARA Program set forth above.

\_\_\_\_\_  
Signature

\_\_\_\_\_  
Name (print or type)

\_\_\_\_\_  
Title

Institution (or Private Practice) Name and Address:

<sup>4</sup> The individual who is authorized to make commitments for the administration of the institution (e.g., hospital administrator, etc.) or, in the case of a private practice, the licensed physician.



# NOTICE TO EMPLOYEES

## YOUR EMPLOYER'S RESPONSIBILITY

Your employer is required to—

1. Apply these NRC regulations and the conditions of his NRC license to all work under the license.
2. Post or otherwise make available to you a copy of the NRC regulations, licenses, and operating procedures which apply to work you are engaged in, and explain their provisions to you.
3. Post Notices of Violation involving radiological working conditions, proposed imposition of civil penalties and orders.
4. Refrain from discriminatory acts against employees who provide information to NRC.

## YOUR RESPONSIBILITY AS A WORKER

You should familiarize yourself with those provisions of the NRC regulations, and the operating procedures which apply to the work you are engaged in. You should observe their provisions for your own protection and protection of your co-workers.

## WHAT IS COVERED BY THESE NRC REGULATIONS

1. Limits on exposure to radiation and radioactive material in restricted and unrestricted areas;
2. Measures to be taken after accidental exposure;
3. Personnel monitoring, surveys and equipment;
4. Caution signs, labels, and safety interlock equipment;
5. Exposure records and reports;
6. Options for workers regarding NRC inspections;
7. Identifies "protected activities" that employees may engage in;
8. Prohibits discrimination against employees who engage in these protected activities;
9. Identifies the Department of Labor as a source of relief in the event of discrimination; and
10. Related matters.

## REPORTS ON YOUR RADIATION EXPOSURE HISTORY

1. The NRC regulations require that your employer give you a written

report if you receive an exposure in excess of any applicable limit as set forth in the regulations or in the license. The basic limits for exposure to employees are set forth in Section 20.101, 20.103, and 20.104 of the Part 20 regulations. These Sections specify limits on exposure to radiation and exposure to concentrations of radioactive material in air.

2. If you work where personnel monitoring is required pursuant to Section 20.202,
  - (a) your employer must give you a written report of your radiation exposures upon the termination of your employment, if you request it, and
  - (b) your employer must advise you annually of your exposure to radiation, if you request it.

## INSPECTIONS

All activities under the license are subject to inspection by representatives of the NRC. In addition, any worker or representative of workers who believes that there is a violation of the Atomic Energy Act of 1954, the regula-

The Nuclear Regulatory Commission (NRC) in its Rules and Regulations: Part 20 has established standards for your protection against radiation hazards from radioactive material under license issued by the NRC; Part 19 has established certain provisions for the options of workers engaged in NRC licensed activities; Parts 30, 40, 50, and other parts containing provisions related to employee protection.

**POSTING REQUIREMENTS** Copies of this notice must be posted in a sufficient number of places in every establishment where activities licensed by the NRC are conducted, to permit employees to observe a copy on the way to or from their place of employment.

tions issued thereunder, or the terms of the employer's license with regard to radiological working conditions in which the worker is engaged, may request an inspection by sending a notice of the alleged violation to the appropriate United States Nuclear Regulatory Commission Regional Office (shown on map below). The request must set forth the specific grounds for the notice, and must be signed by the worker or the representative of the workers. During inspections, NRC inspectors may confer privately with workers, and any worker may bring to the attention of the inspectors any past or present condition which he believes contributed to or caused any violation as described above.

## EMPLOYEE PROTECTION

If an employee believes that discrimination has occurred due to engaging in the "protected activities" said employees may, within 30 days of the discriminatory act, file a complaint with the Department of Labor, Employment Standards Administration, Wage and Hour Division. The Department of Labor shall conduct an investigation

and shall, where discrimination has occurred, issue an order providing relief to the employee if relief is not provided by other means of settlement.

## PROTECTION OF INSPECTORS

The amended Atomic Energy Act, section 235, provides criminal penalties against any individual who kills, forcibly assaults, resists, opposes, impedes, intimidates or interferes with any person who performs any inspections which (1) are related to any activity or facility licensed by the Commission, and (2) are carried out to satisfy requirements under the Atomic Energy Act or under any other Federal law covering the safety of licensed facilities or the safety of radioactive materials. The acts described above are criminal not only if taken against inspection personnel who are engaged in the performance of such inspection duties, but also if taken against inspection personnel on account of such duties.

## SABOTAGE OF NUCLEAR FACILITIES OR FUEL

The amended Atomic Energy Act, section 236, provides criminal penalties against any individual who intentionally and willfully destroys or causes physical damage, or attempts to do so, to any production, utilization, or waste storage facility licensed under the act, or any nuclear fuel or spent fuel regardless of location.

## 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.



NRC FORM 3  
(6-82)

### Regional Offices

REGION	ADDRESS	TELEPHONE
I	U.S. Nuclear Regulatory Commission Region I 831 Park Avenue King of Prussia, PA 19406	215 337-5000
II	U.S. Nuclear Regulatory Commission Region II 101 Marietta St., N.W., Suite 3100 Atlanta, GA 30303	404 221-4503
III	U.S. Nuclear Regulatory Commission Region III 790 Roosevelt Road Glen Ellyn, IL 60137	312 932-2500
IV	U.S. Nuclear Regulatory Commission Region IV 511 Ryan Plaza Drive, Suite 1200 Arlington, TX 76012	817 465-8100
V	U.S. Nuclear Regulatory Commission Region V 1450 Marie Lane, Suite 210 Walnut Creek, CA 94596	415 943-3700