YALE UNIVERSITY

RADIATION SAFETY PROCEDURES

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Yale University

RADIATION SAFETY PROCEDURES

C O N T E N T S

Appendices (continued)

YALE UNIVERSITY

RADIATION SAFETY PROCEDURES

INTRODUCTION

Ionizing radiation is potentially hazardous unless used with strict adherence to safety rules and procedures. Unlike most other such hazards, the risk of unguarded exposure to ionizing radiation includes the possibility of damage to future generations. Thus, the safety rules which govern all uses of ionizing radiation are concerned with preventing genetic damage as well as protecting the health of the exposed individual. When followed faithfully, these rules limit exposure of radiation workers to levels far below those which might cause any adverse somatic or genetic effects. The rules and procedures set forth in this guide have one single, straightforward purpose - to protect employees and the public against unnecessary and potentially harmful exposure to radiation.

Four stages of responsibilities are involved in the radiation safety program. All are equally important:

1. Radiation Safety Committee: This is a group of scientists and physicians appointed by the Yale Administration to establish policies and regulations governing the use of ionizing radiation at Yale.

2. Health Physics Division: An operating unit of specially trained health physicists and technicians which is responsible for insuring compliance with these policies and regulations; it also provides a variety of technical services to the Yale community necessary for achieving such compliance.

3. Authorized Principal Investigators: University faculty members whose training and experience are such that they have been authorized by the Radiation Safety Committee to use ionizing radiation in their laboratory's research activities.

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

GENERAL INFORMATION

	Name	Telephone
Chairman, Radiation Safety Committee	Peter D. Parker	6-2320
Director, Health Physics Division	George R. Holeman	6-0570
Health Physicist	Kenneth W. Price	6-0570
Health Physicist	Frederick Greenhalgh	6-0570
Chief Technician	George Andrews	6-0536
Film Badge Specialist	Lyent W. Russell	6-8434
Senior Administrative Assistant	M. Claire Mulvaney	6-0570
Isotope Secretary	Lorraine Venditto	6-2935
Waste Disposal Service	-	6-0536

RADIATION SAFETY COMMITTEE

The Radiation Safety Committee is composed of members appointed by the President of the University and has jurisdiction over radiation sources and activities in areas under Yale control. The Committee concerns itself primarily with establishing policy.

The functions of the Committee include:

1. Establish policies regarding radiation protection of the Yale community.
2. Provide direction and advice to the Health Physics Division on matters regarding radiation safety policy.
3. Receive, review, and act (through a subcommittee) on all applications for the use of radiation sources in any areas used by Yale personnel.
4. Receive and review periodic reports from the Health Physics Division on monitoring, contamination and personnel exposure.
5. Periodically review the overall use of radiation sources at Yale.
6. Review instances of alleged infraction of use and safety procedures with the Health Physics Division and the responsible individuals.

HEALTH PHYSICS DIVISION

The Health Physics Division is the operational arm of the Radiation Safety Committee and is responsible for:

1. Implementing policy decisions of the Radiation Safety Committee and insuring compliance with various Federal regulations.
2. General surveillance of all health physics activities, including both personnel and environmental monitoring.
3. Furnishing consulting services to personnel at all levels of responsibility on all aspects of radiation protection.
4. Establishment of procedures for purchasing, receiving and shipping all radioactive materials coming to or leaving Yale.
5. Monitoring all University accelerators, isotope laboratories, x-ray machines and other equipment capable of producing ionizing electromagnetic radiations.
6. Distribution and processing of personnel monitoring devices including film badges. The keeping of records of internal and external personnel exposure, and notifying individuals and their supervisors of exposures, as well as recommending appropriate remedial action.
7. Instructing personnel in proper safety procedures for working with radioactive materials or radiation producing equipment.
8. Supervision and coordination of the waste disposal program, including the processing, storage and disposal of radioactive waste and the keeping of the required records.
9. Operation of and the allocation of space in the Isotope Facility, 1138 Kline Biology Tower, and the Cancer Center Radioisotope Facility, 400 Laboratory of Epidemiology and Public Health. These laboratories are equipped for the handling of high levels of activity. Space is available in the above labotatories to any authorized Yale investigator on an allocation basis.

10. Storage of stock solutions involving large quantities of isotopes.

11. Supervising the leak test of all sealed sources and maintaining the required records.

12. Maintaining a quarterly inventory of all radiation materials at Yale.

13. Supervising decontamination in cases of contaminating accidents.

AUTHORIZED PRINCIPAL INVESTIGATOR RESPONSIBILITY

Authorized Principal Investigators are responsible for insuring that the following individual user responsibilities are discharged by those under their control and are further responsible for:

1. Adequate planning of experiments and determination of the type and quantity of radiation or radioactive material to be used. This determination will generally give a good indication of the safety measures that should be employed. Experimental procedures must be well outlined to allow adequate review of safety precautions. Where possible, a cold run using the planned procedures or tracer quantities of radioactive material is recommended to avoid unforeseen safety problems. In any situation where there is appreciable radiation hazard, the Health Physics Division shall be consulted before proceeding.

2. Providing for instruction of those employees for whom they are responsible in the use of safe techniques and in the application of approved radiation safety practices.

3. Furnishing the Health Physics Division with information concerning individuals and activities in their areas, particularly, pertinent changes in their personnel rosters.

4. Contacting the Health Physics Division whenever major changes in operational procedures, new techniques, alterations in physical plant, (for example, the removal of radiochemical fume hood), or when new operations, which might lead to personnel exposure, are anticipated.

5. Complying with the regulations governing the use of radioactive materials as established by the United States Nuclear Regulatory Commission and the Yale Radiation Safety Committee for:

   a. Using proper procurement and transfer procedures. (See Procedures for obtaining Radioactive Materials).

   b. Posting areas where radioisotopes are kept or used, or where radiation fields may exist.

   c. Security of radioisotopes in their possession from unauthorized use.

   d. Recording the receipt, transfer and disposal of radioactive materials in their area. This includes sealed sources, such as ion sources in gas chromatographs and static eliminators. The authorized user must submit inventory data on a quarterly basis.

   e. Assuring that all radioactive waste materials are disposed in accordance with NRC regulation or are transferred to the Health Physics Division for disposal.

   f. Assuring that appropriate records are maintained of work and are reported to the Health Physics Division on a quarterly basis.

   g. Providing adequate instrumentation for assessing potential radiation hazards in their area and performing routine surveys of the work area as necessary.

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

6. Keeping the stock of stored radioactive materials to a minimum within laboratory areas. Authorized users should employ the storage facilities of the Isotope Facility, 1138 Kline Biology Tower or Cancer Center Radioisotope Facility, 400 Laboratory of Epidemiology and Public Health, for shipments not needed in current research.

7. Insuring that service personnel are not permitted to work on equipment, hoods or sinks in radiation areas without the presence of a member of the laboratory staff to provide specific information.

8. Complying with proper procedures for termination of employment or termination of any experiment using radioactive materials. The authorized user must return to the Health Physics Division all radioactive materials, including waste, assigned to him under the license. Particular care should be exercised to see that specialized equipment such as personnel monitoring devices (namely, film badges) are returned to the Health Physics Division. A final termination survey is also necessary.

INDIVIDUAL USER RESPONSIBILITY

Each individual at Yale who has any contact with radioactive materials or radiation producing equipment, is responsible for:

1. Keeping his exposure to radiation as low as possible, and specifically below the maximum permissible exposure as listed in the following table:

Rems Per Calendar Quarter	
Whole body; head and trunk, active blood-forming organs; lens of eyes or gonads.....	1 1/4
Hands and forearms, feet and ankles.....	18 3/4
Skin of whole body.....	7 1/2

Laboratory air and water concentrations shall be maintained below the levels listed in the Code of Federal Regulations, Title 10, Part 20 (10CFR 20) "Standards for Protection Against Radiation". (See Appendix III.). Fetal exposures should be kept below 0.5 rem for the nine month gestation period. (See Appendix VI. for further information).

2. Wearing the prescribed monitoring equipment such as film badges and pocket dosimeters in radiation areas. Personnel who work only with pure alpha emitters, or only with pure beta emitters having a maximum energy of less than 0.2 MeV (namely, ^{3}H, ^{14}C and ^{35}S) will not be required to wear film badges.

3. Surveying their hands, shoes and body for radioactivity and removing all loose contamination before leaving the laboratory.

4. Utilizing all appropriate protective measures such as:

   a. Wearing protective clothing whenever working with radioisotopes, and not wearing such clothing outside of the laboratory area.

   b. Wearing gloves and respiratory protection when necessary.

   c. Using protective barriers and other shields whenever possible.

   d. Using mechanical devices when appropriate to reduce exposure.

   e. Using pipette filling devices. Never pipette radioactive solutions by mouth.

   f. Performing radioactive work within confines of an approved hood or glove box unless serious consideration has indicated the safety of working in the open.

5. Not eating, drinking and/or smoking in areas where radioactive materials are present. Refrigerators may not be used jointly for food, beverages and radioactive materials.

6. Maintaining good personal hygiene. Do not work with radioactive materials if there is open or unprotected break in skin below wrist. Wash hands and arms thoroughly after working with radioactive materials.

7. Checking periodically for contamination in the immediate areas in which radioactive materials are being used (hoods, benches, etc.). Any minor contamination observed should be decontaminated. Large amounts of activity found should be decontaminated under Health Physics Division supervision.

8. Keeping the laboratory neat and clean. The work area should be free from equipment and materials not required for the immediate procedure. Keep or transport materials in such a manner as to prevent breakage or spillage (double container), and to insure adequate shielding. Keep work surfaces covered with plastic-backed absorbent material, preferable in a tray or pan, to limit and collect spillage in case of accident.

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

10. Requesting the Health Physics Division supervision of any emergency repair of contaminated equipment in the laboratory by shop personnel or by commercial service contractors.

11. Reporing accidental inhalation, ingestion, or injury involving radioactive materials to Principal Investigator and the Health Physics Division and carrying out their recommended corrective measures. The individual shall cooperate in any and all attempts to evaluate his exposure. (See Appendix X. for Emergency Plans).

12. Carrying out decontamination procedures when necessary, and taking the necessary steps to prevent the spread of contamination to other areas.

13. Prompt compliance with requests from the Health Physica Division office concerning body burden measurements, the submission of bioassay samples, and scheduling for requested radiation physical examinations.

PROCEDURES FOR OBTAINING RADIOACTIVE MATERIALS

1. Policy

   As a matter of policy, the person applying for authorization must be a Faculty Member (Assistant Professor, Associate Professor or Full Professor) of Yale University. The Isotope Secretary will furnish application forms and necessary information, and is the only person who may order radioactive materials.

2. Authorization Procedures

   a. The Radiation Safety Committee desires to have a minimum of "red tape" to secure isotopes, but not all of it can be eliminated. The Investigator can save time and trouble by following these instructions and by using as much foresight as possible in anticipating his needs.

   b. To obtain moderate amounts of any radioactive materials for use on Yale property only, and not in human beings, secure an application from the Isotope Secretary. These forms must be completed in detail, in duplicate and returned to her. Only <u>one isotope</u> should be requested on each application. A separate sheet may be attached if necessary. These completed forms are circulated to the Radiation Safety Committee, and when approved, a copy is sent to the Investigator for his files. The Investigator may then contact the Isotope Secretary and give her his order, or send a written request or requisition. The Radiation Safety Committee's approval of any application will expire 24 months from date of application.

   c. For isotopes and uses not covered by the University's license, the Radiation Safety Committee and the NRC must both approve. Application is made on the Yale application form.

   d. For Human Use applications, forms may be secured from the Chairman of the Yale-New Haven Hospital Isotope Committee, 120 H.R.T., Section of Nuclear Medicine.

3. Purchasing of Radioactive Material

   After a Principal Investigator has received approval to purchase radioactive material, orders may be placed by telephone with the Isotope Secretary, (6-2935 or 6-2936). When placing an order by telephone give the following information:

   Name of Authorized Principal Investigator.
   Name of person placing the order and telephone number.
   Name of Vendor, catalog number, microcurie or millicurie amount, name of isotope and any special information or instructions. Also charging instructions must be given each time an order is placed.

4. Delivery of Isotopes

   When an isotope is received at the University or Medical School Receiving Rooms, the Isotope Secretary is immediately notified and delivery of the isotope will be made to the Principal Investigator by Receiving Room personnel. The amount and character of the isotope will determine the necessity of the Health Physics Division monitoring the package upon receipt. A recommended procedure for opening radioactive shipments is in Appendix VIII. and should be followed.

5. Transfer of Isotopes

The transfer of isotopes between Investigators and/or laboratories is to be discouraged as a practice, however, where a real need exists the following recommendations apply:

a. Within University facilities: If a Principal Investigator wishes to lend or give isotopes to another Investigator, he should proceed as follows:

The first person can continue to be responsible, and must, therefore, continue to supervise all uses of the isotope as stated herein, or

The second person may take over responsibility, in which case he must notify the Isotope Secretary, fill out the appropriate application for approval and agree to abide by the regulations. Until this is done, the first Investigator is responsible for the use of the isotope.

b. Outside University facilities: No radioactive material may be transferred to, or used, outside Yale facilities, except by special arrangemends with the Committee or its representatives. Special arrangements, depending on circumstances, are initiated by notifying the Isotope Secretary of the proposal.

USE OF ISOTOPES

1. Policy

a. The minimum standards for handling isotopes must meet NRC regulations known as 10CFR Part 20 (See Appendix III.). In addition, the recommendations of the National Council on Radiation Protection and Measurements (NCRP) are considered to be the basis of good practice and are valuable guides, especially NCRP Report 8, "Control and Removal of Radioactive Contamination in Laboratories" and NCRP Report 30, "Safe Handling of Radioactive Materials". A complete list of the NCRP reports is given in Appendix XI..

b. In addition to the Principal Investigators' and users' responsibilities (outlined in the above sections), a set of rules for laboratory work with isotopes is given in Appendix VII..

2. Sources

a. Sealed Sources

Each sealed source containing byproduct material, other than tritium with a half-life greater than thirty days, and in a form other than gas, shall be leak tested at intervals not to exceed six months. For details see Appendix IX..

b. Sources Which are Used Outside the Shielded Containers

These sources must bear a permanently affixed tag having the radiation symbol, and the words, "Caution - Radioactive Material, Do Not Handle, Notify Civil Authorities if Found".

c. Radioactive Foils in Gas Chromatograph Equipment

All gas chromatography units, in which radioactive materials are to be used, are regulated as follows:

As with other radioactive isotopes, the use of radioactive foils in gas chromatography cells must be approved by the Radiation Safety Committee and orders placed through the Health Physics Division. In addition, each cell containing a radioactive foil must have a label showing the radiation caution symbol with the words, "Caution - Radioactive Material", and the identity and activity of the radioactive material. The radioactive foil should not be removed from its identifying cell except for cleaning.

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

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

EMPLOYMENT OF MINORS

Minors who have not reached the age of 18 may not be employed in any area where they may be occupationally exposed to radiation, such as isotope laboratories and areas which contain radiation producing equipment.

CONTROL OF STUDENT EXPOSURE TO RADIATION

The following guides are recommended with respect to the uses of ionizing radiation in educational institutions and should be distributed to students participating in demonstrations and/or experiments involving radiation:

1. Persons in the general population at any age. Such individuals should not receive an exposure exceeding 0.5 rem per year in addition to natural background and medical exposures. This limit applies to those persons who are not occupationally exposed. If an instructor or student of age 18 or greater is subjected routinely to work involving radiation, then he is an occupational workers and the exposure limit of 5 rem per year applies.
2. Persons under 18 years of age. These individuals shall not be occupationally exposed to radiation. Therefore, individuals under 18 years old should not be employed in an isotope laboratory.
3. Students under 18 years of age exposed during educational activities:

   Such individuals should not receive whole body exposure exceeding 0.1 rem per year due to their educational activity. To provide an additional factor of safety, it is recommended that each experiment be so planned that no individual receives more than 0.01 rem while conducting or participating in the experiment.
4. Students over 18 years of age exposed during educational activities fall into category 1. above.

It should be emphasized that there is no difficulty in performing radiation experiments and demonstrations in conformity with the above recommendations, if appropriate safeguards are provided. A handout for students has been prepared and is included in Appendix V..

TRAINING OF NEW EMPLOYEES OR INDIVIDUALS WITH NO PREVIOUS RADIATION EXPERIENCE

10CFR Part 19 requires that each individual entering a restricted area be given information on the radiation hazards to be experienced, biological effects of radiation and techniques of radiation protection, (See Appendix II.). The authorized Principal Investigator is responsible for training the individuals working in his laboratory. The Health Physics Division assists the Investigators by providing routine seminar sessions on radiation safety and radiation protection techniques. Principal Investigators should contact the Health Physics Division when new individuals begin working in their laboratories to arrange for their attendance at one of the seminars.

PERSONNEL DOSIMETRY

It is the intent of the Radiation Safety Committee to maintain occupational radiation exposures at a minimum. In order to accomplish this, the following methods of personnel monitoring are employed:

1. Film Badges

   Except for individuals using soft beta emitters ($E(\beta) < 0.2$ MeV) and pure alpha emitters, everyone directly involved with radioactive materials, or ionizing radiation producing equipment, at University facilities will be required to have and wear a film badge when working. Request forms for film badges may be obtained from the Isotope Secretary and should be sent to the Health Physics Division, Room 12, 340 Edwards Street, (telephone 6-8434). The completed film badge request form should have the following information:

   Name of Applicant (Printed or Typed)
   Date of Birth
   Social Security Number
   Room Number, Building and Department
   Principal Investigator's Name
   Previous Radiation Work History

   Wrist badges are required when handling more than 10 mCi or P-32 and in other situations where the hand exposures may be significant. Wrist badges should also be requested from the Health Physics Division when needed.

2. Bioassays

   Individuals involved in operations which utilize tritium in a form other than a sealed source or metallic foil, in amounts greater than 10 millicuries, will be requested to submit urine samples for analysis. The samples submitted should be taken 24 hours after a single experiment. For continuing experiments, samples may be required at weekly intervals. Arrangements for this service should be made through the Health Physics Division.

3. Thyroid Counts

   Individuals working with iodine isotopes must have thyroid counts on a frequency established by the Health Physics Division.

RADIOACTIVE WASTE DISPOSAL

The United States Nuclear Regulatory Commission (NRC) requires that all licensees maintain written records regarding disposal of radioactive waste material. In order for the University to meet the legal requirements in the above matter, individual Investigators are required to keep records. At quarterly intervals a form will be sent to each Investigator in order to supply the Health Physics Division with a summary of necessary information in the following categories:

Name of isotopes
Methods of disposal
Activities (uCi or mCi of waste)
Special information as necessary

The Health Physics Division will compile the appropriate records from the information supplied by the Investigators for NRC and/or State inspections. Each authorized Investigator is responsible for the secure and safe storage of radioactive waste generated. This generally means storage within the individual's laboratory. In addition, shielding and containment of vapors must be considered by the Investigator.

The following information should be helpful in fulfilling this responsibility and outlines the current Health Physics Division's procedures:

Solid Dry Waste

Special waste receptacles are provided by the Health Physics Division to the various departments utilizing radioactive materials for the disposal of solid dry waste. These receptacles are identified with the magenta and yellow radiation symbol and the words, "Caution - Radioactive Material".

1. Empty containers may be obtained by calling the Health Physics Division, 6-0067 (if no answer, call 6-2935).
2. The corrugated cardboard containers are for solid dry waste only. The contents of these containers should not include liquid, animal tissue of any kind, or items that require refrigeration. Care should be taken to keep containers dry and within the weight capacity of 65 pounds.
3. All syringes used with radioactive isotopes must be capped or the needle removed by mechanical means before discarding them into the waste box.
4. Material must not be put into radioactive waste collection containers if there is any possibility of a chemical reaction during storage or shipment that might cause the release of radioactive gases, fire or explosion. (Special care must be exercised in storing the radioactive waste containing iodine isotopes prior to pick-up due to the volatile nature of iodine).
5. As the receptacle is being filled, records must be kept of the isotopes and quantities being placed in the container.
6. All radioactive waste receptacles must be kept in the laboratory, NOT in the hall or other unsecured area. The presence of the receptacle within the laboratory should not consistute a health hazard. If significant dose rates are associated with the container, special arrangements should be made through the Health Physics Division for recommendations concerning proper shielding or different methods for handling waste arranged.
7. Full containers may be removed by calling the Health Physics Division, (6-0067, if no answer, call 6-2935) giving a two to three day notice. Scheduling for pick-up necessitates advance notice; allowance must be made to anticipate full containers (not overflowing) at the time of pick-up. Investigators are reminded of their responsibility for safe and secure storage of the waste until removed by the Health Physics Division. Each container should be clearly marked indicating what the isotope(s) are and the amount of activity before they are picked up by the Health Physics Division.

8. The waste containers should not be filled to overflowing. The flaps on the top of the container must be folded down and taped in accordance with regulations set forth by the NRC and the Department of Transportation.

9. The solid dry waste is prepared for shipment and sent to an outside vendor to be buried. Due to the expense involved, everyone's cooperation is requested in keeping the waste volume to a minimum by using the containers for radioactive waste only.

Liquid Waste

1. Soluble low-level liquid waste, disposed down the drain, must conform on a University-wide basis, to the NRC regulations. This means limiting the sewage disposal to less than 0.1 millicuries of soluble radioactive material per week, per authorized Investigator. Isotopes having relatively short half-lives can be kept in the laboratory until such time that the activity does not exceed 0.1 millicuries, and then disposed of down the drain. Information on all waste disposed down the drain must be accurately recorded and reported to the Health Physics Division on a quarterly basis.

2. Insoluble or high-level liquid waste must be neutralized (pH 6.5-7.5), collected in inert polyvinyl chloride bottles and the Health Physics Division notified. All iodine liquid waste should be made strongly alkaline. Contents of polyvinyl chloride bottles should be liquid only, (no glass vials, ampoules or paper). It is suggested that the bottles be stored in plastic dishpans or metal trays lined with absorbent material to catch spillage or leakage.

3. To dispose of vials containing unused stock solutions of iodine, wrap the vial in a 4" x 4" square of charcoal impregnated felt (obtained from Health Physics Division) and place in the cylindrical plastic shipping container. Place container in 30 gallon waste drum for disposal.

4. When it is not feasible to pour the contents of liquid scintillation vials down the drain, then metal drums, containing absorbent material, will be provided to collect the intact vials and contents.

5. Liquid waste from P-32 experiments shall be kept separate. If a large volume of P-32 contaminated liquid waste is anticipated, contact the Health Physics Division for a supply of containers to keep it separated from the other isotopes.

6. Lucite rather than lead should be used as the shielding for P-32 waste. If additional shielding is needed use lucite on the inside of the shield and lead on the outside.

Animal Carcasses and Associated Waste

1. Investigators authorized to use animals in their radioisotope research must make adequate provisions for freezing the carcasses until picked up by the Health Physics Division.

2. Bags containing animal carcasses and associated waste should be labeled with isotope, date and quantity contained.

Excess or Unwanted Isotopes and Sources

Contact the Health Physics Division for disposal of unwanted isotopes or sources and disposal will be arranged.

Disposal of Radioactive Viruses

The following suggested disposal procedures were developed in cooperation with the Yale Bio-hazard Committee and should be followed when radioactive compounds and infectious viruses are used together:

1. All liquid preparations containing infectious viruses and radioactive compounds shall be mixed with an appropriate agent such as laundry bleach, or 10 N NaOH to deactivate the virus, then neutralized before placing in the radioactive waste receptacle.
2. All solid waste contaminated with infectious viruses and radioactive compounds should be autoclaved before being placed in the radioactive waste disposal receptacles. Care should be taken that disposable glassware, etc., which might be radioactively contaminated on the outside do not touch the walls of the autoclave.
3. In case of spills or accidents in the laboratory involving both infectious viruses and radioactive compounts, first deactivate the virus and then notify the Health Physics Division and proceed with decontamination as if only radioactive.

If radioactive waste is removed from the laboratory by unauthorized individuals (namely, housekeeping personnel) please contact the Health Physics Division (6-2935 or 6-2936) immediately.

Appendix I.

YALE UNIVERSITY SAFETY POLICY

General Policy

For reasons of humane concern as well as operational efficiency, the University must attend to the safety of its students, faculty and staff and to the protection of its buildings and the irreplaceable fruits of modern research or ancient art they may contain. Therefore, without assuming legal obligations beyond those imposed by law, the University, having in mind the protection of students, personnel and property from injury or loss due to accident, fire or occupational hazard, now reaffirms the following policies and procedures.

University Safety Policy

The Dean of each School, the Master of each College, the Chairman of each Department of Instruction, and the Director or Manager of each University administrative unit, service department or ancillary academic facility, in addition to his other duties, is responsible for the safety of the people and property under his jurisdiction. In fulfilling this responsibility, he may delegate authority to act to members of his faculty or staff; and he will receive assistance from appropriate University organizations, such as the University Fire Marshall, the University Police Department, the Safety Section of the Employee Relations Division, the Health Physics Division and the Environmental Health Section of University Health Services.

University Safety Committee

University safety policy shall be the concern of the University Safety Committee which shall be appointed by the Provost and report directly to the Provost, Treasurer and Director of Operations of the University. This Committee shall consist of one representative of each of the three officers together with the University Police Chief, the University Fire Marshall, the Safety Section Manager and a representative of University Health Services.

In addition to developing general University safety policy the Committee will consider matters which are of general importance or which involve major expenditures and will make recommendations concerning these to the University Officers. When necessary, it will (1) coordinate safety activities in the University, including the work of the professional safety committees and of the area safety committees; (2) review actions and safety regulations formulated by the professional fire safety and health officers and the professional and area committees and (3) assist in promoting or enforcing these.

October, 1975.

Appendix II.

UNITED STATES NUCLEAR REGULATORY COMMISSION

RULES and REGULATIONS

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

PART 19

NOTICES, INSTRUCTIONS, AND REPORTS TO WORKERS; INSPECTIONS

Sec.

AUTHORITY: Secs. 53, 63, 81, 103, 104, 161, Pub. L. 83-703, 68 Stat. 930, 933, 935, 936, 937, 948, as amended (42 U.S.C. 2073, 2093, 2111, 2133, 2134, 2201); Sec. 401, Pub. L. 93-438, 88 stat. 1254 (42 U.S.C. 5891)

§ 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. [40 FR 8774]

§ 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, or 70 of this chapter, including persons licensed to operate a production or utilization facility pursuant to Part 50 of this chapter.

§ 19.3 Definitions.

[39 FR 22217]

As used in this part:

(a) "Act" means the Atomic Energy Act of 1954, (68 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, or 70 of this chapter, including licenses to operate a production or utilization facility pursuant to Part 50 of this chapter. "Licensee" means the holder of such a license.

[38 FR 22217]

(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.

[40 FR 8774]

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.

§ 19.11 Posting of notices to workers.

[38 FR 22217]

(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.

[38 FR 22217]

(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.

[40 FR 8774]

(c) Form NRC-3, "Notice to Employees", shall be posted by each licensee wherever individuals work in or frequent any portion of a restricted area.

NOTE: Copies of Form NRC-3 may be obtained by writing to the Director of the appropriate U.S. Nuclear Regulatory Commission Inspection and Enforcement Regional Office listed in Appendix "D", Part 20 of this chapter, or the Director, Office of Inspection and Enforcement, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555.

[38 FR 22217]

(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.

§ 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 license, 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 pursuant to this section need not be limited to matters referred to in the complaint.

(c) No licensee shall discharge or in any manner discriminate against any worker because such worker has filed any complaint or instituted or caused to be instituted any proceeding under the regulations in this chapter or has testified or is about to testify in any such proceeding or because of the exercise by such worker on behalf of himself or others of any option afforded by this part.

§ 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 posi-

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tion 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).

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§ 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.

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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.

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§ 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.

40 FR 8774

UNITED STATES NUCLEAR REGULATORY COMMISSION

RULES and REGULATIONS

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

PART 20

STANDARDS FOR PROTECTION AGAINST RADIATION

GENERAL PROVISIONS

PERMISSIBLE DOSES, LEVELS, AND CONCENTRATIONS

PRECAUTIONARY PROCEDURES

WASTE DISPOSAL

RECORDS, REPORTS, AND NOTIFICATION

EXCEPTIONS AND ADDITIONAL REQUIREMENTS

ENFORCEMENT

AUTHORITY: The provisions of this Part 20 issued under secs. 53, 63, 65, 81, 103, 104, 161, 68 Stat. 930, 933, 935, 936, 937, 948, as amended; 42 U.S.C. 2073, 2093, 2095, 2111, 2133, 2134, 2201. For the purposes of sec. 223, 68 Stat. 958, as amended; 42 U.S.C. 2273, §§ 20.401-20.409, issued under sec. 161 o., 68 Stat. 950, as amended; 42 U.S.C. 2201 (o). Secs. 202, 206, Pub. L. 93-438, 88 Stat. 1244, 1246 (42 U.S.C. 5842, 5846).

40 FR 8774

§ 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.

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(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 exposure to such material and to radiation from such material, when added to exposures to unlicensed radioactive material and to other unlicensed sources of radiation in the possession of the licensee, and to radiation therefrom, does not exceed the standards of radiation protection prescribed in the regulations in this part.

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(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.

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§ 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, or 70 of this chapter, including persons licensed to operate a production or utilization facility pursuant to Part 50 of this chapter.

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40 FR 42387

§ 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;

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(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.

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

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(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 byproduct 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 Part 30, 40, or 70 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 Administration (except that the Administration 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) "Administration" means the Energy Research and Development Administration or its duly authorized representatives.

(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 tissue 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;

(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 subparagraph (3) of this paragraph, 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/cm²)	Average flux to deliver 100 millirem in 40 hours (neutrons/cm² per sec.)
Thermal	970×10^6	670
0.0001	720×10^6	500
0.005	820×10^6	570
0.02	400×10^6	280
0.1	120×10^6	80
0.5	43×10^6	30
1.0	26×10^6	18
2.5	29×10^6	20
5.0	25×10^6	18
7.5	24×10^6	17
10	24×10^6	17
10 to 30	14×10^6	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 = 3.7×10^{10} disintegrations per second (dps) = 2.2×10^{12} disintegrations per minute (dpm). Commonly used submultiples of the curie are the millicurie and the microcurie:

(1) One millicurie (mCi) [1] = 0.001 curie (Ci) [1] = 3.7×10^7 dps.

(2) One microcurie (μCi) [1] = 0.000001 curie = 3.7×10^4 dps.

[1] Wherever possible, the appropriate unit should be written out as "curie(s)," "millicurie(s)," or "microcurie(s)," and the abbreviations should not be used.

(b) [Deleted 40 FR 50704.]

(c) [Deleted 39 FR 23990.]

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§ 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.

40 FR 8774

§ 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.

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** Permissible Dose, Levels, and Concentrations

§ 20.101 Exposure of individuals to radiation in restricted areas.

(a) 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 in the licensee's possession a dose in excess of the limits specified in the following table:

Rems per calendar quarter

1. Whole body, head and trunk; active blood-forming organs; lens of eyes; or gonads	1¼
2. Hands and forearms; feet and ankles	18¾
3. Skin of whole body	7½

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

(1) During any calendar quarter the dose to the whole body from radioactive material and other sources of radiation in the licensee's possession 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.

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§ 20.102 Determination of accumulated dose.

(a) This section contains requirements which must be satisfied by licensees who propose, pursuant to paragraph (b) of § 20.101, to permit individuals in a restricted area to receive exposure to radiation in excess of the limits specified in paragraph (a) of § 20.101.

(b) Before permitting any individual in a restricted area to receive exposure to radiation in excess of the limits specified in paragraph (a) of § 20.101, each licensee shall:

(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 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:

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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.	3¾	1¼

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

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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.

41 FR 52300

§ 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.[1] [2] [3] 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 [4] 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

[1] 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.

[2] 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 materials shall be subject to the precautionary procedures required by § 20.103(b)(1).

[3] Multiply * the concentration values specified in Appendix B, Table I, column 1 by 6.3×10^{6} ml to obtain the quarterly quantity limit.

Footnotes 4 and 5 on page 20-4.

** Amended 36 FR 1466.

* Amended 42 FR 20138.

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[4] 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 1, 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 may make allowance for such use in estimating exposures of individuals to such materials provided that such equipment is used as stipulated in Regulatory Guide 8.15, "Acceptable Programs for Respiratory Protection."[5]

(d) Notwithstanding the provisions of paragraphs (b) and (c) of this section, the Commission may impose further restrictions:

(1) On the extent to which a licensee may make allowance for use of respirators in lieu of provision of process, containment, ventilation, or other engineering controls, if application of such controls is found to be practicable; and

(2) As might be necessary to assure that the respiratory protective program of the licensee is adequate in limiting exposures of personnel to airborne radioactive materials.

(e) 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.

(f) A licensee who was authorized to make allowance for use of respiratory protective equipment prior to December 29, 1976 shall bring his respiratory protective program into conformance with the requirements of paragraph (c) of this section within one year of that date, and is exempt from the requirement of paragraph (e) of this section.

[4] 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.

[5] 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.

[6] This incorporation by reference provision was approved by the Director of the Federal Register on October 19, 1976. Single copies of Regulatory Guide 8.15 are available from the Office of Standards Development, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, upon written request.

41 FR 52300

41 FR 52300

41 FR 52300

§ 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.

25 FR 10914

(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.

41 FR 52300

§ 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.

25 FR 10914

(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.

29 FR 14434

§ 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.

(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 (p^H) 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 reconcentrations 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 this section do not apply to disposal of radioactive material into sanitary sewerage systems, which is governed by § 20.303

[39 FR 14434]

[39 FR 14434]

§ 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.

[39 FR 14434]

§ 20.108 Orders requiring furnishing of bio-assay services.

Where necessary or desirable in order to aid in determining the extent of an

PART 20 • STANDARDS FOR PROTECTION AGAINST RADIATION

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.

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 may be necessary for him to comply with the regulations in this part.

§ 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.

[25 FR 10914]

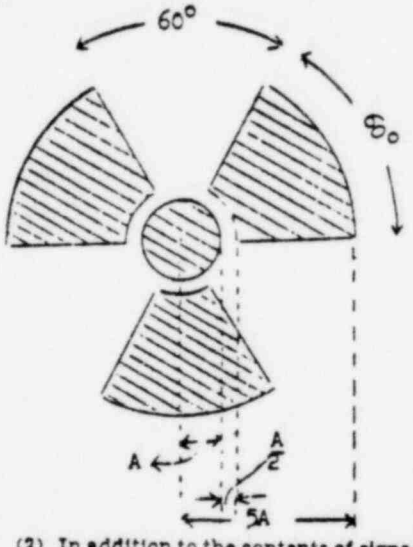
[36 FR 5033]

§ 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[1]
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[1]
HIGH RADIATION AREA

(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 subparagraph (2) of this paragraph 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 subparagraph (2) of this paragraph.

(5) Any licensee, or applicant for a license, may apply to the Commission for approval of methods not included in subparagraphs (2) and (4) of this paragraph 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 subparagraph (3) of this paragraph is met.

[35 FR 5033]

(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[1]
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:

CAUTION[1]
RADIOACTIVE MATERIAL(S)

(2) Each area or room in which natural uranium or thorium is used or stored in an 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[1]
RADIOACTIVE MATERIAL(S)

(f) *Containers.* (1) Except as provided in subparagraph (3) of this paragraph, each container of licensed mate-

[1] Or "Danger"

rial shall bear a durable, clearly visible label identifying the radioactive contents.

(2) A label required pursuant to subparagraph (1) of this paragraph shall bear the radiation caution symbol and the words "CAUTION, RADIOACTIVE MATERIAL" or "DANGER, RADIOACTIVE MATERIAL". It shall also provide sufficient information[1] 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 subparagraph (1) of this paragraph, 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 Column 2, Table I, Appendix B 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[2] 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.

31 FR 10614

§ 20.204 Same: exceptions.

25 FR 10914

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 byproduct 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.

35 FR 6033

(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.

25 FR 10914

35 FR 5033

(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.

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

39 FR 17972

(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.

39 FR 17972

TABLE OF EXEMPT AND TYPE A QUANTITIES

Transport group[1]	Exempt quantity limit (in millicuries)	Type A quantity limit (in curies)
I	.01	0.001
II	0.1	0.050
III	1	3
IV	1	20
V	1	20
VI	1	1000
VII	10,000	1000
Special Form	1	20

39 FR 17972

41 FR 16445

(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.

39 FR 22220

§ 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.

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

[2] For example, containers in locations such as water-filled canals, storage vaults, or hot cells.

* Amended 34 FR 19546.

[1] The definitions of "transport group" and "special form" are specified in § 71.4 of this chapter.

† Amended 41 FR 16445.

40 FR 26679

§ 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 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 Part 30, 40, or 70 of this chapter, whichever may be applicable; or

(b) As authorized pursuant to § 20.302; or

(c) As provided in § 20.303 or § 20.304, applicable respectively to the disposal of licensed material by release into sanitary sewerage systems or burial in soil, or in § 20.106 (Radioactivity in Effluents to Unrestricted Areas).

25 FR 10914

§ 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.

26 FR 352

*(b) The Commission will not approve any application for a license to receive licensed material from other persons for disposal on land not owned by the Federal government or by a State government.

36 FR 23138

(c) 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.

25 FR 10914

§ 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 subparagraphs (1) or (2) of this paragraph:

(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 released into the sewerage system by the licensee does not exceed one curie per year.

Excreta from individuals undergoing medical diagnosis or therapy with radioactive material shall be exempt from any limitations contained in this section.

25 FR 10914

§ 20.304 Disposal by burial in soil.

No licensee shall dispose of licensed material by burial in soil unless:

(a) The total quantity of licensed and other radioactive materials buried at any one location and time does not exceed, at the time of burial, 1,000 times the amount specified in Appendix C of this part; and

(b) Burial is at a minimum depth of four feet; and

(c) Successive burials are separated by distances of at least six feet and not more than 12 burials are made in any year.

§ 20.305 Treatment or disposal by incineration.

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

RECORDS, REPORTS, AND NOTIFICATION

39 FR 17972

§ 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, and 20.304.

(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.

41 FR 18300

(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 material made pursuant to §§ 20.302, 20.303, or 20.304 shall 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.

34 FR 7500

§ 20.402 Reports of theft or loss of licensed material.

(a) Each licensee shall report by telephone and telegraph, mailgram, or facsimile,† to the Director of the appropriate Nuclear Regulatory Commission Inspection and Enforcement Regional Office listed in Appendix D, immediately after its occurrence becomes known to the licensee, any loss or theft of licensed material in such quantities and under such circumstances that it appears to the licensee that a substantial hazard may result to persons in unrestricted areas.

41 FR 16445

(b) Each licensee who is required to make a report pursuant to paragraph (a) of this section shall, within thirty (30) days after he learns of the loss or theft, make a report in writing to the appropriate NRC Regional Office listed in Appendix D with copies to the Director of Inspection and Enforcement, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, setting forth the following information:

*Redesignated 36 FR 23138.

†Amended 41 FR 16445.

(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.

[34 FR 7560]

[41 FR 16445]

§ 20.403 Notifications of incidents.

(a) *Immediate notification.* Each licensee shall immediately notify by telephone and telegraph, mailgram, or facsimile, the Director of the appropriate NRC Regional Office listed in Appendix

D of any incident involving byproduct, source, or special nuclear material possessed by him and which 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; 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 $100,000.

(b) *Twenty-four hour notification.* Each licensee shall within 24 hours notify by telephone and telegraph, mailgram, or facsimile, the Director of the appropriate NRC Regional Office listed in Appendix D of any incident involving licensed material possessed by him and which 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; or

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

(4) Damage to property in excess of $1,000.

(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.

§ 20.404 [Deleted 38 FR 22220.]

§ 20.405 Reports of overexposures and excessive levels and concentrations.

(a) In addition to any notification required by § 20.403, each licensee shall make a report in writing within 30 days to the appropriate NRC Regional Office listed in Appendix D with a copy to the Director of Inspection and Enforcement, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, of:

(1) each exposure of an individual to radiation in excess of the applicable limits in §§ 20.101 or 20.104 (a) or the license; (2) each exposure of an individual to radioactive material in excess of the applicable limits in §§ 20.103(a)(1), 20.103(a)(2), 20.104(b) or the license; (3) levels of radiation or concentrations of radioactive material in a restricted area in excess of any other applicable limit in the license; (4) any incident for which notification is required by § 20.403; and (5) 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. Each report required under this paragraph shall describe the extent of exposure of persons to radiation or to radioactive material, including estimates of each individual's exposure as required by paragraph (b) of this section; levels of radiation and concentrations of radioactive material involved; the cause of the exposure, levels or concentrations; and corrective steps taken or planned to assure against a recurrence.

(b) Any report filed with the Commission pursuant to 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) [Deleted 38 FR 22220.]

§ 20.406 [Deleted 38 FR 22220.]

§ 20.407 Personnel exposure and monitoring reports.

(a) This section applies to each person licensed by the Commission or the Atomic Energy 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, fabrication, 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; or

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

Radionuclide[1]	*Quantity in curies*
Cesium-137	1
Cobalt-60	1
Gold-198	100
Iodine-131	1
Iridium-192	10
Krypton-85	1,000
Promethium-147	10
Technetium-99m	1,000

(b) Each person described in paragraph (a) of this section shall, within the first quarter of each calendar year, submit to the Director of Inspection and Enforcement, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555,† the following reports, applicable to the described licensed activities covering the preceding calendar year:*

(1) A report of either (i) 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 (ii) the total number of individuals for whom personnel monitoring was provided during the calendar year; *Provided*, that such total includes at least the number of individuals required to be reported under paragraph (b)(1)(i) of this section. The report shall indicate whether it is submitted in accordance with paragraph (b)(1)(i) or (ii) of this section.

(2) 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 § 20.407(b)(1), indicating the number of individuals whose total whole body exposure recorded during the previous calendar year was in each of the following estimated exposure ranges:

Estimated Whole Body Exposure Range (Rems)[2]	*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+	

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 exposure on termination of employment or work.

When an individual terminates employment with a licensee subject to § 20.407, or an individual assigned to work in such a licensee's facility, but not employed by the licensee, completes his work assignment in the licensee's facility, the licensee shall furnish* to the Director of Inspection and Enforcement,† U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, a report of the individual's exposure to radiation and radioactive material, incurred during the

[1] 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.

† Amended 41 FR 16445.

* 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.

[2] Individual values exactly equal to the values separating Exposure Ranges shall be reported in the higher range.

* Amended 38 FR 22220.

34 FR 5264

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.

38 FR 22220

§ 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 any 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.

EXCEPTIONS AND ADDITIONAL REQUIREMENTS

25 FR 10914

§ 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.

40 FR 8774

§ 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.

APPENDIX A [Reserved]

APPENDIX B

Concentrations in Air and Water Above Natural Background

(See footnotes on page 20-15)

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

APPENDIX B

Concentrations in Air and Water Above Natural Background—Continued

(See footnotes on page 20-15)

Element (atomic number)	Isotope [1]	†	Table I Column 1 Air (μCi/ml)	Table I Column 2 Water (μCi/ml)	Table II Column 1 Air (μCi/ml)	Table II Column 2 Water (μCi/ml)
Bromine (35)	Br 82	S	1×10^{-6}	8×10^{-6}	4×10^{-8}	3×10^{-7}
		I	2×10^{-7}	1×10^{-6}	6×10^{-9}	4×10^{-8}
Cadmium (48)	Cd 109	S	5×10^{-8}	5×10^{-6}	2×10^{-9}	2×10^{-7}
		I	7×10^{-8}	5×10^{-6}	3×10^{-9}	2×10^{-7}
	Cd 115m	S	4×10^{-8}	7×10^{-7}	1×10^{-9}	3×10^{-8}
		I	4×10^{-8}	7×10^{-7}	1×10^{-9}	3×10^{-8}
	Cd 115	S	2×10^{-7}	1×10^{-6}	8×10^{-9}	3×10^{-8}
		I	2×10^{-7}	1×10^{-6}	6×10^{-9}	4×10^{-8}
Calcium (20)	Ca 45	S	3×10^{-8}	3×10^{-7}	1×10^{-9}	9×10^{-8}
		I	1×10^{-7}	5×10^{-6}	4×10^{-9}	2×10^{-7}
	Ca 47	S	2×10^{-7}	1×10^{-6}	6×10^{-9}	5×10^{-8}
		I	2×10^{-7}	1×10^{-6}	6×10^{-9}	3×10^{-8}
Californium (98)	Cf 249	S	2×10^{-12}	1×10^{-7}	5×10^{-14}	4×10^{-9}
		I	1×10^{-10}	7×10^{-7}	3×10^{-12}	2×10^{-8}
	Cf 250	S	5×10^{-12}	4×10^{-7}	2×10^{-13}	1×10^{-8}
		I	1×10^{-10}	7×10^{-7}	3×10^{-12}	3×10^{-8}
	Cf 251	S	2×10^{-12}	1×10^{-7}	6×10^{-14}	4×10^{-9}
		I	1×10^{-10}	8×10^{-7}	3×10^{-12}	3×10^{-8}
	Cf 252	* S	6×10^{-12}	2×10^{-7}	2×10^{-13}	7×10^{-9}
		* I	3×10^{-11}	2×10^{-7}	1×10^{-12}	7×10^{-9}
	Cf 253	S	8×10^{-10}	4×10^{-6}	3×10^{-11}	1×10^{-7}
		I	8×10^{-10}	4×10^{-6}	3×10^{-11}	1×10^{-7}
	Cf 254	S	5×10^{-12}	4×10^{-9}	2×10^{-13}	1×10^{-7}
		I	5×10^{-12}	4×10^{-9}	2×10^{-13}	1×10^{-7}
Carbon (6)	C 14	S	4×10^{-6}	2×10^{-7}	1×10^{-7}	8×10^{-7}
	(CO_2)	Sub	5×10^{-5}		1×10^{-6}	
Cerium (58)	Ce 141	S	4×10^{-7}	3×10^{-6}	2×10^{-8}	9×10^{-8}
		I	2×10^{-7}	3×10^{-6}	5×10^{-9}	9×10^{-8}
	Ce 143	S	3×10^{-7}	1×10^{-6}	9×10^{-9}	4×10^{-8}
		I	2×10^{-7}	1×10^{-6}	7×10^{-9}	4×10^{-8}
	Ce 144	S	1×10^{-8}	3×10^{-7}	3×10^{-10}	1×10^{-8}
		I	6×10^{-9}	3×10^{-7}	2×10^{-10}	1×10^{-8}
Cesium (55)	Cs 131	S	1×10^{-6}	7×10^{-6}	4×10^{-7}	2×10^{-6}
		I	3×10^{-6}	3×10^{-6}	1×10^{-7}	9×10^{-7}
	Cs 134m	S	4×10^{-6}	2×10^{-6}	1×10^{-7}	6×10^{-8}
		I	6×10^{-6}	3×10^{-6}	2×10^{-7}	1×10^{-6}
	Cs 134	S	4×10^{-8}	3×10^{-7}	1×10^{-9}	9×10^{-8}
		I	1×10^{-8}	1×10^{-6}	4×10^{-10}	4×10^{-8}
	Cs 135	S	5×10^{-7}	3×10^{-6}	2×10^{-8}	1×10^{-7}
		I	9×10^{-8}	7×10^{-6}	3×10^{-9}	2×10^{-7}
	Cs 136	S	4×10^{-7}	2×10^{-6}	1×10^{-8}	9×10^{-8}
		I	2×10^{-7}	2×10^{-6}	6×10^{-9}	6×10^{-8}
	Cs 137	S	6×10^{-8}	4×10^{-7}	2×10^{-9}	2×10^{-8}
		I	1×10^{-8}	1×10^{-6}	5×10^{-10}	4×10^{-8}
Chlorine (17)	Cl 36	S	4×10^{-7}	2×10^{-6}	1×10^{-8}	8×10^{-8}
		I	2×10^{-8}	2×10^{-6}	8×10^{-10}	6×10^{-8}
	Cl 38	S	3×10^{-6}	1×10^{-6}	9×10^{-8}	4×10^{-7}
		I	2×10^{-6}	1×10^{-6}	7×10^{-8}	4×10^{-7}
Chromium (24)	Cr 51	S	1×10^{-5}	5×10^{-5}	4×10^{-7}	2×10^{-6}
		I	2×10^{-6}	5×10^{-5}	8×10^{-8}	2×10^{-6}

APPENDIX B

Concentrations in Air and Water Above Natural Background—Continued

(See footnotes on page 20-15)

Element (atomic number)	Isotope [1]	†	Table I Column 1 Air (μCi/ml)	Table I Column 2 Water (μCi/ml)	Table II Column 1 Air (μCi/ml)	Table II Column 2 Water (μCi/ml)
Cobalt (27)	Co 57	S	3×10^{-6}	2×10^{-3}	1×10^{-7}	5×10^{-5}
		I	2×10^{-7}	1×10^{-5}	6×10^{-9}	4×10^{-6}
	Co 58m	S	2×10^{-5}	8×10^{-3}	6×10^{-7}	3×10^{-5}
		I	9×10^{-6}	6×10^{-5}	3×10^{-7}	2×10^{-5}
	Co 58	S	8×10^{-7}	4×10^{-5}	3×10^{-8}	1×10^{-6}
		I	5×10^{-8}	3×10^{-5}	2×10^{-9}	9×10^{-7}
	Co 60	S	3×10^{-7}	1×10^{-5}	1×10^{-8}	5×10^{-7}
		I	9×10^{-9}	1×10^{-5}	3×10^{-10}	3×10^{-7}
Copper (29)	Cu 64	S	2×10^{-6}	1×10^{-5}	7×10^{-8}	3×10^{-6}
		I	1×10^{-6}	6×10^{-5}	4×10^{-9}	2×10^{-6}
Curium (96)	Cm 242	S	1×10^{-10}	7×10^{-6}	4×10^{-12}	2×10^{-7}
		W, I	2×10^{-10}	7×10^{-6}	6×10^{-12}	2×10^{-7}
	Cm 243	S	6×10^{-12}	1×10^{-6}	2×10^{-13}	5×10^{-8}
		I	1×10^{-10}	7×10^{-6}	3×10^{-12}	2×10^{-7}
	Cm 244	S	9×10^{-12}	2×10^{-6}	3×10^{-13}	7×10^{-8}
		I	1×10^{-10}	8×10^{-6}	3×10^{-12}	3×10^{-7}
	Cm 245	S	5×10^{-12}	1×10^{-6}	2×10^{-13}	4×10^{-8}
		I	1×10^{-10}	8×10^{-6}	4×10^{-12}	3×10^{-7}
	Cm 246	S	5×10^{-12}	1×10^{-6}	2×10^{-13}	4×10^{-8}
		I	1×10^{-10}	8×10^{-6}	4×10^{-12}	3×10^{-7}
	Cm 247	S	5×10^{-12}	1×10^{-6}	2×10^{-13}	4×10^{-8}
		I	1×10^{-10}	6×10^{-6}	4×10^{-12}	2×10^{-7}
	Cm 248	S	6×10^{-13}	1×10^{-7}	2×10^{-14}	4×10^{-9}
		I	1×10^{-11}	4×10^{-7}	4×10^{-13}	1×10^{-8}
	Cm 249	S	1×10^{-7}	6×10^{-3}	4×10^{-7}	2×10^{-3}
		I	1×10^{-7}	6×10^{-3}	4×10^{-7}	2×10^{-3}
Dysprosium (66)	Dy 165	S	3×10^{-6}	1×10^{-3}	9×10^{-8}	4×10^{-6}
		I	2×10^{-6}	1×10^{-3}	7×10^{-8}	4×10^{-6}
	Dy 166	S	2×10^{-7}	1×10^{-3}	8×10^{-9}	4×10^{-7}
		I	2×10^{-7}	1×10^{-3}	7×10^{-9}	4×10^{-7}
Einsteinium (99)	Es 253	S	8×10^{-10}	7×10^{-6}	3×10^{-11}	2×10^{-7}
		I	6×10^{-10}	7×10^{-6}	2×10^{-11}	2×10^{-7}
	Es 254m	S	5×10^{-9}	5×10^{-6}	2×10^{-10}	2×10^{-7}
		I	6×10^{-9}	5×10^{-6}	2×10^{-10}	2×10^{-7}
	Es 254	S	2×10^{-11}	4×10^{-6}	6×10^{-13}	1×10^{-7}
		I	1×10^{-10}	4×10^{-6}	4×10^{-12}	1×10^{-7}
	Es 255	S	5×10^{-10}	8×10^{-6}	2×10^{-11}	3×10^{-7}
		I	4×10^{-10}	8×10^{-6}	1×10^{-11}	3×10^{-7}
Erbium (68)	Er 169	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	9×10^{-7}
		I	4×10^{-7}	3×10^{-3}	1×10^{-8}	9×10^{-7}
	Er 171	S	7×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-6}
		I	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-6}
Europium (63)	Eu 152	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-7}
	(T/2 = 9.2 hrs)	I	3×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-7}
	Eu 152	S	1×10^{-6}	2×10^{-3}	4×10^{-10}	8×10^{-7}
	(T/2 = 13 yrs)	I	2×10^{-6}	2×10^{-3}	6×10^{-10}	8×10^{-7}
	Eu 154	S	4×10^{-7}	6×10^{-4}	1×10^{-10}	2×10^{-7}
		I	7×10^{-7}	6×10^{-4}	2×10^{-10}	2×10^{-7}
	Eu 155	S	9×10^{-6}	6×10^{-3}	3×10^{-9}	2×10^{-6}
		I	7×10^{-6}	6×10^{-3}	3×10^{-9}	2×10^{-6}

APPENDIX B

Concentrations in Air and Water Above Natural Background—Continued

(See footnotes on page 20-16)

Element (atomic number)	Isotope [1]	†	Table I Column 1 Air (μCi/ml)	Table I Column 2 Water (μCi/ml)	Table II Column 1 Air (μCi/ml)	Table II Column 2 Water (μCi/ml)
Promium (100)	Pm 254	S	6×10^{-9}	4×10^{-3}	2×10^{-9}	1×10^{-6}
		I	7×10^{-9}	4×10^{-3}	2×10^{-9}	1×10^{-6}
	Pm 255	S	2×10^{-9}	1×10^{-3}	6×10^{-10}	3×10^{-7}
		I	1×10^{-9}	1×10^{-3}	4×10^{-10}	3×10^{-7}
	Pm 256	S	3×10^{-9}	3×10^{-3}	1×10^{-10}	9×10^{-7}
		I	2×10^{-9}	3×10^{-3}	6×10^{-11}	9×10^{-7}
Fluorine (9)	P 18	S	8×10^{-6}	2×10^{-3}	2×10^{-7}	8×10^{-6}
		I	3×10^{-6}	1×10^{-3}	9×10^{-8}	5×10^{-6}
Gadolinium (64)	Gd 153	S	2×10^{-7}	6×10^{-3}	8×10^{-9}	2×10^{-6}
		I	9×10^{-8}	6×10^{-3}	3×10^{-9}	2×10^{-6}
	Gd 159	S	5×10^{-7}	2×10^{-3}	2×10^{-8}	8×10^{-7}
		I	4×10^{-7}	2×10^{-3}	1×10^{-8}	8×10^{-7}
Gallium (31)	Ga 72	S	2×10^{-7}	1×10^{-3}	8×10^{-9}	4×10^{-7}
		I	2×10^{-7}	1×10^{-3}	6×10^{-9}	4×10^{-7}
Germanium (32)	Ge 71	S	1×10^{-6}	8×10^{-3}	4×10^{-7}	2×10^{-6}
		I	6×10^{-6}	5×10^{-3}	2×10^{-7}	2×10^{-6}
Gold (79)	Au 196	S	1×10^{-6}	8×10^{-3}	4×10^{-8}	2×10^{-6}
		I	6×10^{-7}	4×10^{-3}	2×10^{-8}	1×10^{-6}
	Au 198	S	3×10^{-7}	2×10^{-3}	1×10^{-8}	5×10^{-7}
		I	2×10^{-7}	1×10^{-3}	8×10^{-9}	5×10^{-7}
	Au 199	S	1×10^{-6}	8×10^{-3}	4×10^{-8}	2×10^{-6}
		I	8×10^{-7}	4×10^{-3}	3×10^{-8}	2×10^{-6}
Hafnium (72)	Hf 181	S	4×10^{-6}	2×10^{-3}	1×10^{-7}	7×10^{-6}
		I	7×10^{-6}	2×10^{-3}	3×10^{-7}	7×10^{-6}
Holmium (67)	Ho 166	S	2×10^{-7}	9×10^{-4}	7×10^{-9}	3×10^{-6}
		I	2×10^{-7}	9×10^{-4}	6×10^{-9}	3×10^{-6}
Hydrogen (1)	H3	S	5×10^{-6}	1×10^{-1}	2×10^{-7}	3×10^{-3}
		I	5×10^{-6}	1×10^{-1}	2×10^{-7}	3×10^{-3}
		Sub	2×10^{-3}		4×10^{-9}	
Indium (49)	In 113m	S	8×10^{-6}	4×10^{-3}	3×10^{-7}	1×10^{-6}
		I	7×10^{-6}	4×10^{-3}	2×10^{-7}	1×10^{-6}
	In 114m	S	1×10^{-7}	5×10^{-4}	4×10^{-9}	2×10^{-7}
		I	2×10^{-6}	5×10^{-4}	7×10^{-10}	2×10^{-7}
	In 115m	S	2×10^{-6}	1×10^{-3}	8×10^{-9}	4×10^{-7}
		I	2×10^{-6}	1×10^{-3}	6×10^{-9}	4×10^{-7}
	In 115	S	2×10^{-7}	3×10^{-3}	9×10^{-9}	9×10^{-7}
		I	2×10^{-6}	3×10^{-3}	1×10^{-9}	9×10^{-7}
Iodine (53)	I 125	S	5×10^{-9}	4×10^{-3}	8×10^{-11}	2×10^{-7}
		I	2×10^{-7}	6×10^{-3}	6×10^{-9}	2×10^{-6}
	I 126	S	8×10^{-9}	5×10^{-3}	9×10^{-11}	3×10^{-7}
		I	3×10^{-7}	3×10^{-3}	1×10^{-9}	9×10^{-7}
	I 129	S	2×10^{-9}	1×10^{-3}	2×10^{-11}	6×10^{-9}
		I	7×10^{-9}	6×10^{-3}	2×10^{-9}	2×10^{-6}
	I 131	S	9×10^{-9}	6×10^{-3}	1×10^{-10}	3×10^{-7}
		I	3×10^{-7}	2×10^{-3}	1×10^{-9}	6×10^{-9}
	I 132	S	2×10^{-7}	2×10^{-3}	3×10^{-9}	8×10^{-9}
		I	9×10^{-7}	5×10^{-3}	3×10^{-9}	2×10^{-6}
	I 133	S	3×10^{-8}	3×10^{-4}	4×10^{-10}	1×10^{-6}
		I	2×10^{-7}	1×10^{-3}	7×10^{-9}	4×10^{-6}
	I 134	S	5×10^{-7}	4×10^{-3}	6×10^{-9}	2×10^{-6}

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APPENDIX B

Concentrations in Air and Water Above Natural Background—Continued

(See footnotes on page 20-15)

Element (atomic number)	Isotope [1]	†	Table I Column 1 Air (μCi/ml)	Table I Column 2 Water (μCi/ml)	Table II Column 1 Air (μCi/ml)	Table II Column 2 Water (μCi/ml)
Iodine (53)	I 134	I	3×10^{-6}	2×10^{-3}	1×10^{-7}	6×10^{-6}
	I 135	S	1×10^{-7}	7×10^{-6}	1×10^{-9}	4×10^{-8}
		I	4×10^{-7}	2×10^{-3}	1×10^{-8}	7×10^{-8}
Iridium (77)	Ir 190	S	1×10^{-6}	6×10^{-3}	4×10^{-8}	2×10^{-6}
		I	4×10^{-7}	5×10^{-3}	1×10^{-8}	2×10^{-6}
	Ir 192	S	1×10^{-7}	1×10^{-3}	4×10^{-9}	4×10^{-7}
		I	3×10^{-8}	1×10^{-3}	9×10^{-10}	4×10^{-7}
	Ir 194	S	2×10^{-7}	1×10^{-3}	8×10^{-9}	3×10^{-7}
		I	2×10^{-7}	9×10^{-4}	5×10^{-9}	3×10^{-7}
Iron (26)	Fe 55	S	9×10^{-7}	2×10^{-3}	3×10^{-8}	8×10^{-6}
		I	1×10^{-6}	7×10^{-3}	3×10^{-8}	2×10^{-7}
	Fe 59	S	1×10^{-7}	2×10^{-3}	5×10^{-9}	6×10^{-7}
		I	5×10^{-8}	2×10^{-3}	2×10^{-9}	5×10^{-7}
Krypton (36)	Kr 85m	Sub	6×10^{-6}		1×10^{-7}	
	Kr 85	Sub	1×10^{-5}		3×10^{-7}	
	Kr 87	Sub	1×10^{-6}		2×10^{-8}	
	Kr 88	Sub	1×10^{-6}		2×10^{-8}	
Lanthanum (57)	La 140	S	2×10^{-7}	7×10^{-6}	5×10^{-9}	2×10^{-7}
		I	1×10^{-7}	7×10^{-6}	4×10^{-9}	2×10^{-8}
Lead (82)	Pb 203	S	3×10^{-6}	1×10^{-3}	9×10^{-8}	4×10^{-6}
		I	2×10^{-6}	1×10^{-3}	6×10^{-8}	4×10^{-6}
	Pb 210	S	1×10^{-10}	4×10^{-6}	4×10^{-12}	1×10^{-7}
		I	2×10^{-10}	5×10^{-3}	8×10^{-12}	2×10^{-6}
	Pb 212	S	2×10^{-8}	6×10^{-6}	6×10^{-10}	2×10^{-7}
		I	2×10^{-8}	5×10^{-6}	7×10^{-10}	2×10^{-7}
Lutetium (71)	Lu 177	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-6}
		I	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-6}
Manganese (25)	Mn 52	S	2×10^{-7}	1×10^{-3}	7×10^{-9}	3×10^{-7}
		I	1×10^{-7}	9×10^{-4}	5×10^{-9}	3×10^{-7}
	Mn 54	★ S	4×10^{-7}	4×10^{-3}	1×10^{-8}	1×10^{-6}
		I	4×10^{-8}	3×10^{-3}	1×10^{-9}	1×10^{-6}
	Mn 56	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-6}
		I	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-6}
Mercury (80)	Hg 197m	S	7×10^{-7}	6×10^{-3}	3×10^{-8}	2×10^{-6}
		I	8×10^{-7}	5×10^{-3}	3×10^{-8}	2×10^{-6}
	Hg 197	S	1×10^{-6}	9×10^{-3}	4×10^{-8}	3×10^{-6}
		I	3×10^{-6}	1×10^{-3}	9×10^{-8}	5×10^{-6}
	Hg 203	S	7×10^{-8}	5×10^{-6}	2×10^{-9}	2×10^{-8}
		I	1×10^{-7}	3×10^{-3}	4×10^{-9}	1×10^{-6}
Molybdenum (42)	Mo 99	S	7×10^{-7}	5×10^{-3}	3×10^{-8}	2×10^{-6}
		I	2×10^{-7}	1×10^{-3}	7×10^{-9}	4×10^{-7}
Neodymium (60)	Nd 144	S	8×10^{-11}	2×10^{-3}	3×10^{-12}	7×10^{-9}
		I	3×10^{-10}	2×10^{-3}	1×10^{-11}	8×10^{-9}
	Nd 147	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-9}
		I	2×10^{-7}	2×10^{-3}	8×10^{-9}	6×10^{-9}
	Nd 149	S	2×10^{-6}	8×10^{-3}	6×10^{-8}	3×10^{-6}
		I	1×10^{-6}	8×10^{-3}	5×10^{-8}	3×10^{-6}

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APPENDIX B

Concentrations in Air and Water Above Natural Background—Continued

(See footnotes on page 20-15)

Element (atomic number)	Isotope [1]	†	Table I Column 1 Air (μCi/ml)	Table I Column 2 Water (μCi/ml)	Table II Column 1 Air (μCi/ml)	Table II Column 2 Water (μCi/ml)
Neptunium (93)	Np 237	S	4×10^{-12}	9×10^{-5}	1×10^{-13}	3×10^{-6}
		I	1×10^{-10}	9×10^{-4}	4×10^{-12}	3×10^{-5}
	Np 239	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-6}
		I	7×10^{-7}	4×10^{-3}	2×10^{-8}	1×10^{-6}
Nickel (28)	Ni 59	S	3×10^{-7}	6×10^{-3}	2×10^{-8}	2×10^{-6}
		I	8×10^{-7}	6×10^{-2}	3×10^{-8}	2×10^{-5}
	Ni 63	S	6×10^{-8}	8×10^{-4}	2×10^{-9}	3×10^{-5}
		I	3×10^{-7}	2×10^{-2}	1×10^{-8}	7×10^{-6}
	Ni 65	S	9×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-6}
		I	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-6}
Niobium (Columbium) (41)	Nb 93m	S	1×10^{-7}	1×10^{-3}	4×10^{-9}	4×10^{-6}
		I	2×10^{-7}	1×10^{-3}	5×10^{-9}	4×10^{-6}
	Nb 95	S	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-6}
		I	1×10^{-7}	3×10^{-3}	3×10^{-9}	1×10^{-6}
	Nb 97	S	6×10^{-6}	3×10^{-3}	2×10^{-7}	9×10^{-6}
		I	5×10^{-6}	3×10^{-3}	2×10^{-7}	9×10^{-6}
Osmium (76)	Os 185	S	5×10^{-7}	2×10^{-3}	2×10^{-8}	7×10^{-7}
		I	5×10^{-8}	2×10^{-3}	2×10^{-9}	7×10^{-7}
	Os 191m	S	2×10^{-5}	7×10^{-3}	6×10^{-7}	3×10^{-5}
		I	9×10^{-6}	7×10^{-3}	3×10^{-7}	2×10^{-5}
	Os 191	S	1×10^{-6}	5×10^{-3}	4×10^{-8}	2×10^{-6}
		I	4×10^{-7}	5×10^{-3}	1×10^{-8}	2×10^{-6}
	Os 193	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-7}
		I	3×10^{-7}	2×10^{-3}	9×10^{-9}	5×10^{-7}
Palladium (46)	Pd 103	S	1×10^{-6}	1×10^{-3}	5×10^{-8}	3×10^{-6}
		I	7×10^{-7}	8×10^{-3}	3×10^{-8}	3×10^{-6}
	Pd 109	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	9×10^{-7}
		I	4×10^{-7}	2×10^{-3}	1×10^{-8}	7×10^{-7}
Phosphorus (15)	P 32	S	7×10^{-8}	5×10^{-4}	2×10^{-9}	2×10^{-7}
		I	8×10^{-8}	7×10^{-4}	3×10^{-9}	2×10^{-7}
Platinum (78)	Pt 191	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-6}
		I	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-6}
	Pt 193m	S	7×10^{-6}	3×10^{-3}	2×10^{-7}	1×10^{-5}
		I	5×10^{-6}	3×10^{-3}	2×10^{-7}	1×10^{-5}
	★ Pt 193	S	1×10^{-6}	3×10^{-3}	4×10^{-8}	9×10^{-6}
		I	3×10^{-7}	5×10^{-3}	1×10^{-8}	2×10^{-5}
	Pt 197m	S	6×10^{-8}	3×10^{-3}	2×10^{-7}	1×10^{-5}
		I	5×10^{-6}	3×10^{-3}	2×10^{-7}	9×10^{-6}
	Pt 197	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-6}
		I	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-6}
Plutonium (94)	Pu 238	S	2×10^{-13}	1×10^{-4}	7×10^{-14}	5×10^{-8}
		I	3×10^{-11}	8×10^{-4}	1×10^{-12}	3×10^{-5}
	Pu 239	S	2×10^{-13}	1×10^{-4}	6×10^{-14}	5×10^{-8}
		I	4×10^{-11}	8×10^{-4}	1×10^{-12}	3×10^{-5}
	Pu 240	S	2×10^{-13}	1×10^{-4}	6×10^{-14}	5×10^{-8}
		I	4×10^{-11}	8×10^{-4}	1×10^{-12}	3×10^{-5}
	Pu 241	S	9×10^{-11}	7×10^{-3}	3×10^{-13}	2×10^{-4}
		I	4×10^{-9}	4×10^{-3}	1×10^{-9}	1×10^{-3}

APPENDIX B

Concentrations in Air and Water Above Natural Background—Continued

(See footnotes on page 20-15)

Element (atomic number)	Isotope [1]	†	Table I Column 1 Air (μCi/ml)	Table I Column 2 Water (μCi/ml)	Table II Column 1 Air (μCi/ml)	Table II Column 2 Water (μCi/ml)
Plutonium (94)	Pu 243	S	2×10^{-12}	1×10^{-6}	6×10^{-14}	3×10^{-8}
		I	4×10^{-11}	9×10^{-6}	1×10^{-12}	3×10^{-7}
	Pu 243	S	2×10^{-6}	1×10^{-3}	6×10^{-8}	3×10^{-4}
		I	2×10^{-6}	1×10^{-3}	8×10^{-8}	3×10^{-4}
	Pu 244	S	2×10^{-12}	1×10^{-6}	6×10^{-14}	4×10^{-8}
		I	3×10^{-11}	3×10^{-6}	1×10^{-12}	1×10^{-7}
Polonium (84)	Po 210	S	5×10^{-10}	2×10^{-3}	2×10^{-11}	7×10^{-7}
		I	2×10^{-10}	8×10^{-6}	7×10^{-12}	3×10^{-7}
Potassium (19)	K 42	S	3×10^{-6}	9×10^{-3}	7×10^{-8}	3×10^{-4}
		I	1×10^{-7}	6×10^{-6}	4×10^{-9}	2×10^{-7}
Praseodymium (59)	Pr 142	S	2×10^{-7}	9×10^{-6}	7×10^{-9}	3×10^{-7}
		I	2×10^{-7}	9×10^{-6}	8×10^{-9}	3×10^{-7}
	Pr 143	S	3×10^{-7}	1×10^{-5}	1×10^{-8}	5×10^{-7}
		I	2×10^{-7}	1×10^{-5}	6×10^{-9}	3×10^{-7}
Promethium (61)	Pm 147	S	6×10^{-9}	6×10^{-5}	2×10^{-9}	2×10^{-6}
		I	1×10^{-7}	6×10^{-5}	3×10^{-9}	2×10^{-6}
	Pm 149	S	3×10^{-7}	1×10^{-5}	1×10^{-8}	4×10^{-7}
		I	2×10^{-7}	1×10^{-5}	8×10^{-9}	4×10^{-7}
Protoactinium (91)	Pa 230	S	2×10^{-9}	7×10^{-5}	6×10^{-11}	2×10^{-6}
		I	8×10^{-10}	7×10^{-5}	3×10^{-11}	2×10^{-6}
	Pa 231	S	1×10^{-13}	3×10^{-9}	4×10^{-14}	9×10^{-8}
		I	1×10^{-10}	8×10^{-6}	4×10^{-12}	2×10^{-7}
	Pa 233	S	6×10^{-7}	4×10^{-3}	2×10^{-8}	1×10^{-6}
		I	2×10^{-7}	3×10^{-3}	6×10^{-9}	1×10^{-6}
Radium (88)	Ra 223	S	2×10^{-9}	2×10^{-5}	6×10^{-11}	7×10^{-7}
		I	2×10^{-10}	1×10^{-6}	8×10^{-12}	4×10^{-8}
	Ra 224	S	8×10^{-9}	7×10^{-5}	2×10^{-10}	2×10^{-6}
		I	7×10^{-10}	2×10^{-6}	2×10^{-11}	8×10^{-8}
	Ra 226	S	3×10^{-11}	4×10^{-7}	3×10^{-13}	3×10^{-9}
		I	8×10^{-11}	9×10^{-6}	2×10^{-12}	3×10^{-8}
	Ra 228	S	7×10^{-11}	8×10^{-7}	2×10^{-13}	3×10^{-9}
		I	4×10^{-11}	7×10^{-6}	1×10^{-12}	3×10^{-8}
Radon (86)	Rn 220	S	3×10^{-7}		1×10^{-9}	
	Rn 222 [3]	S	*** 3×10^{-8}		3×10^{-9}	
Rhenium (75)	Re 183	S	3×10^{-6}	2×10^{-3}	9×10^{-8}	6×10^{-6}
		I	2×10^{-7}	8×10^{-5}	5×10^{-9}	3×10^{-6}
	Re 186	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	9×10^{-6}
		I	2×10^{-7}	1×10^{-3}	8×10^{-9}	5×10^{-6}
	Re 187	S	9×10^{-6}	7×10^{-3}	3×10^{-7}	2×10^{-5}
		I	5×10^{-7}	4×10^{-3}	2×10^{-8}	2×10^{-5}
	Re 188	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-6}
		I	2×10^{-7}	9×10^{-4}	6×10^{-9}	3×10^{-6}
Rhodium (45)	Rh 103m	S	8×10^{-5}	4×10^{-1}	3×10^{-6}	1×10^{-2}
		I	6×10^{-5}	3×10^{-1}	2×10^{-6}	1×10^{-2}
	Rh 105	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
Rubidium (37)	Rb 86	S	3×10^{-7}	2×10^{-3}	1×10^{-8}	7×10^{-5}
		I	7×10^{-9}	7×10^{-4}	2×10^{-9}	2×10^{-5}
	Rb 87	S	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	7×10^{-9}	5×10^{-3}	2×10^{-9}	2×10^{-4}

APPENDIX B

Concentrations in Air and Water Above Natural Background—Continued

(See footnotes on page 20-15)

Element (atomic number)	Isotope [1]	†	Table I Column 1 Air (μCi/ml)	Table I Column 2 Water (μCi/ml)	Table II Column 1 Air (μCi/ml)	Table II Column 2 Water (μCi/ml)
Ruthenium (44)	Ru 97	S	2×10^{-6}	1×10^{-3}	8×10^{-8}	4×10^{-4}
		I	2×10^{-6}	1×10^{-3}	6×10^{-8}	3×10^{-4}
	Ru 103	S	3×10^{-7}	2×10^{-3}	2×10^{-8}	8×10^{-5}
		I	8×10^{-9}	2×10^{-3}	3×10^{-8}	8×10^{-5}
	Ru 105	S	7×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
	Ru 106	S	8×10^{-9}	4×10^{-4}	3×10^{-8}	1×10^{-5}
		I	6×10^{-9}	3×10^{-4}	2×10^{-10}	1×10^{-5}
Samarium (62)	Sm 147	S	7×10^{-11}	2×10^{-3}	2×10^{-12}	6×10^{-8}
		I	3×10^{-10}	2×10^{-3}	9×10^{-12}	7×10^{-8}
	Sm 151	S	6×10^{-9}	1×10^{-2}	2×10^{-9}	4×10^{-7}
		I	1×10^{-7}	1×10^{-2}	8×10^{-9}	4×10^{-7}
	Sm 153	S	5×10^{-7}	2×10^{-3}	2×10^{-8}	8×10^{-5}
		I	4×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
Scandium (21)	Sc 46	S	2×10^{-7}	1×10^{-3}	8×10^{-9}	4×10^{-6}
		I	2×10^{-9}	1×10^{-3}	8×10^{-11}	4×10^{-6}
	Sc 47	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	9×10^{-5}
		I	5×10^{-7}	3×10^{-3}	2×10^{-8}	9×10^{-5}
	Sc 48	S	2×10^{-7}	8×10^{-4}	6×10^{-9}	3×10^{-5}
		I	1×10^{-7}	8×10^{-4}	5×10^{-9}	3×10^{-5}
Selenium (34)	Se 75	S	1×10^{-6}	9×10^{-3}	4×10^{-8}	3×10^{-4}
		I	1×10^{-7}	8×10^{-3}	4×10^{-9}	3×10^{-4}
Silicon (14)	Si 31	S	6×10^{-6}	3×10^{-2}	2×10^{-7}	9×10^{-4}
		I	1×10^{-6}	4×10^{-2}	3×10^{-8}	2×10^{-4}
Silver (47)	Ag 105	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	8×10^{-9}	3×10^{-3}	3×10^{-8}	1×10^{-4}
	Ag 110m	S	2×10^{-7}	9×10^{-4}	7×10^{-9}	3×10^{-5}
		I	1×10^{-9}	9×10^{-4}	3×10^{-10}	3×10^{-5}
	Ag 111	S	3×10^{-7}	1×10^{-3}	1×10^{-8}	4×10^{-5}
		I	2×10^{-7}	1×10^{-3}	8×10^{-9}	4×10^{-5}
Sodium (11)	Na 22	S	2×10^{-7}	1×10^{-3}	6×10^{-9}	4×10^{-5}
		I	9×10^{-9}	9×10^{-4}	3×10^{-10}	3×10^{-5}
	Na 24	S	1×10^{-6}	6×10^{-3}	4×10^{-8}	2×10^{-4}
		I	1×10^{-7}	6×10^{-3}	5×10^{-9}	2×10^{-4}
Strontium (38)	Sr 85m	S	4×10^{-6}	2×10^{-2}	1×10^{-7}	7×10^{-4}
		I	3×10^{-6}	2×10^{-2}	1×10^{-7}	7×10^{-4}
	Sr 85	S	2×10^{-7}	3×10^{-3}	8×10^{-9}	1×10^{-4}
		I	1×10^{-7}	3×10^{-3}	4×10^{-9}	1×10^{-4}
	Sr 89	S	2×10^{-8}	3×10^{-4}	3×10^{-10}	3×10^{-5}
		I	4×10^{-9}	8×10^{-4}	1×10^{-9}	3×10^{-5}
	Sr 90	S	1×10^{-9}	1×10^{-3}	3×10^{-11}	3×10^{-7}
		I	5×10^{-9}	1×10^{-3}	2×10^{-10}	4×10^{-7}
	Sr 91	S	4×10^{-7}	2×10^{-3}	2×10^{-8}	7×10^{-5}
		I	2×10^{-7}	1×10^{-3}	9×10^{-9}	5×10^{-5}
	Sr 92	S	4×10^{-7}	2×10^{-3}	2×10^{-8}	7×10^{-5}
		I	3×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
Sulfur (16)	S 35	S	3×10^{-7}	2×10^{-3}	9×10^{-9}	6×10^{-5}
		I	3×10^{-7}	8×10^{-4}	9×10^{-9}	3×10^{-5}
Tantalum (73)	Ta 182	S	4×10^{-9}	1×10^{-3}	1×10^{-9}	4×10^{-5}
		I	2×10^{-9}	1×10^{-3}	7×10^{-10}	4×10^{-5}

APPENDIX B

Concentrations in Air and Water Above Natural Background—Continued

(See footnotes on page 20-15)

Element (atomic number)	Isotope [1]	†	Table I Column 1 Air (μCi/ml)	Table I Column 2 Water (μCi/ml)	Table II Column 1 Air (μCi/ml)	Table II Column 2 Water (μCi/ml)
Technetium (43)	Tc 96m	S	8×10^{-3}	4×10^{-1}	3×10^{-4}	1×10^{-2}
		I	3×10^{-3}	3×10^{-1}	1×10^{-4}	1×10^{-2}
	Tc 96	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	2×10^{-7}	1×10^{-3}	8×10^{-9}	5×10^{-5}
	Tc 97m	S	2×10^{-6}	1×10^{-2}	8×10^{-8}	4×10^{-4}
		I	2×10^{-7}	5×10^{-3}	5×10^{-9}	2×10^{-4}
	Tc 97	S	1×10^{-5}	5×10^{-2}	4×10^{-7}	2×10^{-3}
		I	3×10^{-7}	2×10^{-3}	1×10^{-8}	8×10^{-5}
	Tc 99m	S	4×10^{-5}	2×10^{-1}	1×10^{-6}	6×10^{-3}
		I	1×10^{-5}	8×10^{-2}	5×10^{-7}	3×10^{-3}
	Tc 99	S	2×10^{-6}	1×10^{-2}	7×10^{-8}	3×10^{-4}
		I	6×10^{-8}	5×10^{-3}	2×10^{-9}	2×10^{-4}
Tellurium (52)	Te 125m	S	4×10^{-7}	5×10^{-3}	1×10^{-8}	2×10^{-4}
		I	1×10^{-7}	3×10^{-3}	4×10^{-9}	1×10^{-4}
	Te 127m	S	1×10^{-7}	2×10^{-3}	5×10^{-9}	6×10^{-5}
		I	4×10^{-8}	2×10^{-3}	1×10^{-9}	5×10^{-5}
	Te 127	S	2×10^{-6}	8×10^{-3}	6×10^{-8}	3×10^{-4}
		I	9×10^{-7}	5×10^{-3}	3×10^{-8}	2×10^{-4}
	Te 129m	S	8×10^{-8}	1×10^{-3}	3×10^{-9}	3×10^{-5}
		I	3×10^{-8}	6×10^{-4}	1×10^{-9}	2×10^{-5}
	Te 129	S	5×10^{-6}	2×10^{-2}	2×10^{-7}	8×10^{-4}
		I	4×10^{-6}	2×10^{-2}	1×10^{-7}	8×10^{-4}
	Te 131m	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
		I	2×10^{-7}	1×10^{-3}	6×10^{-9}	4×10^{-5}
	Te 132	S	2×10^{-7}	9×10^{-4}	7×10^{-9}	3×10^{-5}
		I	1×10^{-7}	6×10^{-4}	4×10^{-9}	2×10^{-5}
Terbium (65)	Tb 160	S	1×10^{-7}	1×10^{-3}	3×10^{-9}	4×10^{-5}
		I	3×10^{-8}	1×10^{-3}	1×10^{-9}	4×10^{-5}
Thallium (81)	Tl 200	S	3×10^{-6}	1×10^{-2}	9×10^{-8}	4×10^{-4}
		I	1×10^{-6}	7×10^{-3}	4×10^{-8}	2×10^{-4}
	Tl 201	S	2×10^{-6}	9×10^{-3}	7×10^{-8}	3×10^{-4}
		I	9×10^{-7}	5×10^{-3}	3×10^{-8}	2×10^{-4}
	Tl 202	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	2×10^{-7}	2×10^{-3}	8×10^{-9}	7×10^{-5}
	Tl 204	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	3×10^{-6}	2×10^{-2}	9×10^{-10}	6×10^{-5}
Thorium (90) *	Th 227	S	3×10^{-10}	5×10^{-6}	1×10^{-11}	2×10^{-7}
		I	2×10^{-10}	5×10^{-6}	6×10^{-12}	2×10^{-7}
	Th 228	S	9×10^{-13}	2×10^{-8}	3×10^{-14}	7×10^{-10}
		I	6×10^{-13}	4×10^{-8}	2×10^{-14}	1×10^{-9}
	Th 230	S	2×10^{-12}	5×10^{-8}	8×10^{-14}	2×10^{-9}
		I	1×10^{-11}	9×10^{-8}	3×10^{-13}	3×10^{-9}
	Th 231 *	S	1×10^{-6}	7×10^{-3}	5×10^{-8}	2×10^{-4}
		I	1×10^{-6}	7×10^{-3}	4×10^{-8}	2×10^{-4}
	Th 232	S	3×10^{-11}	5×10^{-8}	1×10^{-13}	2×10^{-9}
		I	3×10^{-11}	1×10^{-7}	1×10^{-13}	4×10^{-9}
	Th natural **	S	6×10^{-11}	6×10^{-8}	2×10^{-13}	2×10^{-9}
		I	6×10^{-11}	6×10^{-8}	2×10^{-13}	2×10^{-9}

APPENDIX B

Concentrations in Air and Water Above Natural Background—Continued

(See footnotes on page 20-15)

Element (atomic number)	Isotope [1]	†	Table I Column 1 Air (μCi/ml)	Table I Column 2 Water (μCi/ml)	Table II Column 1 Air (μCi/ml)	Table II Column 2 Water (μCi/ml)
Thorium (90)	Th 234	S	6×10^{-8}	5×10^{-4}	2×10^{-9}	2×10^{-5}
		I	3×10^{-8}	5×10^{-4}	1×10^{-9}	2×10^{-5}
Thulium (69)	Tm 170	S	4×10^{-8}	1×10^{-3}	1×10^{-9}	5×10^{-5}
		I	3×10^{-8}	1×10^{-3}	1×10^{-9}	5×10^{-5}
	Tm 171	S	1×10^{-7}	1×10^{-2}	4×10^{-9}	5×10^{-4}
		I	2×10^{-7}	1×10^{-2}	8×10^{-9}	5×10^{-4}
Tin (50)	Sn 113	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	9×10^{-5}
		I	5×10^{-8}	2×10^{-3}	2×10^{-9}	8×10^{-5}
	Sn 125	S	1×10^{-7}	5×10^{-4}	4×10^{-9}	2×10^{-5}
		I	8×10^{-8}	5×10^{-4}	3×10^{-9}	2×10^{-5}
Tungsten (Wolfram) (74)	W 181	S	2×10^{-6}	1×10^{-2}	8×10^{-8}	4×10^{-4}
		I	1×10^{-7}	1×10^{-2}	4×10^{-9}	3×10^{-4}
	W 185	S	8×10^{-7}	4×10^{-2}	3×10^{-8}	1×10^{-4}
		I	1×10^{-7}	3×10^{-2}	4×10^{-9}	1×10^{-4}
	W 187	S	4×10^{-7}	2×10^{-3}	2×10^{-8}	7×10^{-5}
		I	3×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
Uranium (92)	U 230	S	3×10^{-10}	1×10^{-4}	1×10^{-11}	5×10^{-6}
		I	1×10^{-10}	1×10^{-4}	4×10^{-12}	5×10^{-6}
	U 232	S	1×10^{-10}	8×10^{-4}	3×10^{-12}	3×10^{-5}
		I	3×10^{-11}	8×10^{-4}	9×10^{-13}	3×10^{-5}
	U 232	S	5×10^{-10}	9×10^{-4}	2×10^{-11}	3×10^{-5}
		I	1×10^{-10}	9×10^{-4}	4×10^{-12}	3×10^{-5}
	U 234 **	S [4]	6×10^{-10}	9×10^{-4}	2×10^{-11}	3×10^{-5}
		I	1×10^{-10}	9×10^{-4}	4×10^{-12}	3×10^{-5}
	U 235 **	S [4]	5×10^{-10}	8×10^{-4}	2×10^{-11}	3×10^{-5}
		I	1×10^{-10}	8×10^{-4}	4×10^{-12}	3×10^{-5}
	U 236	S	6×10^{-10}	1×10^{-3}	2×10^{-11}	4×10^{-5}
		I	1×10^{-10}	1×10^{-3}	4×10^{-12}	3×10^{-5}
	U 238 **	S [4]	7×10^{-11}	1×10^{-3}	3×10^{-12}	4×10^{-5}
		I	1×10^{-10}	1×10^{-3}	5×10^{-12}	4×10^{-5}
	U 240	S	2×10^{-7}	1×10^{-3}	8×10^{-9}	3×10^{-5}
		I	2×10^{-7}	1×10^{-3}	6×10^{-9}	3×10^{-5}
	U-natural **	S [4]	1×10^{-10}	1×10^{-3}	3×10^{-12}	3×10^{-5}
		I	1×10^{-10}	1×10^{-3}	5×10^{-12}	3×10^{-5}
Vanadium (23)	V 48	S	2×10^{-7}	9×10^{-4}	6×10^{-9}	3×10^{-5}
		I	6×10^{-8}	8×10^{-4}	2×10^{-9}	3×10^{-5}
Xenon (54)	Xe 131m	Sub	2×10^{-5}		4×10^{-7}	
	Xe 133	Sub	1×10^{-5}		3×10^{-7}	
	Xe 133m	Sub	1×10^{-5}		3×10^{-7}	
	Xe 135	Sub	4×10^{-6}		1×10^{-7}	
Ytterbium (70)	Yb 175	S	7×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
Yttrium (39)	Y 90	S	1×10^{-7}	6×10^{-4}	4×10^{-9}	2×10^{-5}
		I	1×10^{-7}	6×10^{-4}	3×10^{-9}	2×10^{-5}
	Y 91m	S	2×10^{-5}	1×10^{-1}	8×10^{-7}	3×10^{-3}
		I	2×10^{-5}	1×10^{-1}	6×10^{-7}	3×10^{-3}
	Y 91	S	4×10^{-8}	8×10^{-4}	1×10^{-9}	3×10^{-5}
		I	3×10^{-8}	8×10^{-4}	1×10^{-9}	3×10^{-5}
	Y 92	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
		I	3×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
	Y 93	S	2×10^{-7}	8×10^{-4}	6×10^{-9}	3×10^{-5}
		I	1×10^{-7}	8×10^{-4}	5×10^{-9}	3×10^{-5}

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41 FR 16804
25 FR 10914
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Concentrations in Air and Water Above Natural Background—Continued

(See footnotes on page 20-15)

Element (atomic number)	Isotope [1]		Table I		Table II	
			Column 1	Column 2	Column 1	Column 2
			Air (μCi/ml)	Water (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)
Zinc (30)	Zn 65	S	1×10^{-7}	3×10^{-3}	4×10^{-9}	1×10^{-4}
		I	6×10^{-8}	5×10^{-3}	2×10^{-9}	2×10^{-4}
	Zn 69m	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	7×10^{-5}
		I	3×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
	Zn 69	S	7×10^{-6}	5×10^{-2}	2×10^{-7}	2×10^{-3}
		I	9×10^{-6}	5×10^{-2}	3×10^{-7}	2×10^{-3}
Zirconium (40)	Zr 93	S	1×10^{-7}	2×10^{-3}	4×10^{-9}	8×10^{-5}
		I	3×10^{-7}	2×10^{-3}	1×10^{-8}	8×10^{-5}
	Zr 95	S	1×10^{-7}	2×10^{-3}	4×10^{-9}	6×10^{-5}
		I	3×10^{-8}	2×10^{-3}	1×10^{-8}	6×10^{-5}
	Zr 97	S	1×10^{-7}	5×10^{-4}	4×10^{-9}	2×10^{-5}
		I	9×10^{-8}	5×10^{-4}	3×10^{-8}	2×10^{-5}
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.		Sub	1×10^{-6}		3×10^{-8}	
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.			3×10^{-8}	9×10^{-5}	1×10^{-10}	3×10^{-6}
Any single radionuclide not listed above, which decays by alpha emission or spontaneous fission.			6×10^{-12}	4×10^{-7}	2×10^{-14}	3×10^{-9}

[1] Soluble (S); Insoluble (I).

[2] "Sub" means that values given are for submersion in a semispherical infinite cloud of airborne material.

[3] 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 (⅓) "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 1.3×10^5 MeV of alpha particle energy.) The Table II value may be replaced by one-thirtieth (1/30) of a "working level." The limit on radon-222 concentrations in restricted areas may be based on an annual average.

[4] 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 0.2 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 8×10^{-4} SA μCi-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 6.77×10^{-7} curies per gram U. The specific activity for other mixtures of U-238, U-235 and U-234, if not known, shall be:

$SA = 3.6 \times 10^{-7}$ curies/gram U (U-depleted $E \geq 0.72$)

$SA = (0.4 + 0.38\,E + 0.0034\,E^2)\ 10^{-6}$

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.

25 FR 10914, Nov. 14, 1960, as amended at 39 FR 23990, June 27, 1974; 40 FR 50704, Oct. 31, 1975

NOTE TO APPENDIX B

[25 FR 10914]

NOTE: In any case where there is a mixture in air or water of more than one radionuclide, the limiting values for purposes of this Appendix should be determined as follows:

1. If the identity and concentration of each radionuclide in the mixture are known, the limiting values should be derived as follows: Determine, for each radionuclide in the mixture, the ratio between the quantity present in the mixture and the limit otherwise established in Appendix B for the specific radionuclide when not in a mixture. The sum of such ratios for all the radionuclides in the mixture may not exceed "1" (i.e., "unity").

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, and MPC_B, and MPC_C respectively, then the concentrations shall be limited so that the following relationship exists:

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

[30 FR 15801]

2. If either the identity or the concentration of any radionuclide in the mixture is not known, the limiting values for purposes of Appendix B shall be:

a. For purposes of Table I, Col. 1—6×10^{-13}

b. For purposes of Table I, Col. 2—4×10^{-7}

c. For purposes of Table II, Col. 1—2×10^{-11}

d. For purposes of Table II, Col. 2—3×10^{-6}

[26 FR 11046]

3. If any of the conditions specified below are met, the corresponding values specified below may be used in lieu of those specified in paragraph 2 above.

a. If the identity of each radionuclide in the mixture is known but the concentration of one or more of the radionuclides in the mixture is not known, the concentration limit for the mixture is the limit specified in Appendix "B" for the radionuclide in the mixture having the lowest concentration limit; or

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

[30 FR 15801]

c. Element (atomic number) and isotope	Table I		Table II	
	Column 1 Air (μCi/ml)	Column 2 Water (μCi/ml)	Column 1 Air (μCi/ml)	Column 2 Water (μCi/ml)
If it is known that Sr 90, I 126, I 129, I 131, (I 133, table II only), Pb 210, Po 210, At 211, Ra 223, Ra 224, Ra 226, Ac 227, Ra 228, Th 230, Pa 231, Th nat, Tb-nat, Cm 248, Cf 254, and Fm 256 are not present		9×10^{-9}		3×10^{-6}
If it is known that Sr 90, I 125, I 126, I 129, (I 131, I 133, table II only), Pb 210, Po 210, Ra 223, Ra 226, Ra 228, Pa 231, Th-nat, Cm 248, Cf 254, and Fm 256 are not present		6×10^{-9}		2×10^{-6}
If it is known that Sr 90, I 126, (I 125, I 129, I 131, table II only), Pb 210, Ra 226, Ra 228, Cm 248, and Cf 254 are not present		2×10^{-9}		6×10^{-7}
If it is known that (I 129, table II only), Ra 226, and Ra 228 are not present		3×10^{-9}		1×10^{-7}
If it is known that alpha-emitters and Sr 90, I 129, Pb 210, Ac 227, Ra 228, Pa 230, Pu 241, and Bk 249 are not present	3×10^{-13}		1×10^{-10}	
If it is known that alpha-emitters and Pb 210, Ac 227, Ra 228, and Pu 241 are not present	3×10^{-12}		1×10^{-11}	
If it is known that alpha-emitters and Ac 227 are not present	3×10^{-11}		1×10^{-9}	
If it is known that Ac 227, Th 230, Pa 231, Pu 238, Pu 239, Pu 240, Pu 242, Pu 244, Cm 248, Cf 249 and Cf 251 are not present	3×10^{-13}		1×10^{-10}	

[40 FR 50704]

4. If a mixture of radionuclides consists of uranium and its daughters in ore dust prior to chemical separation of the uranium from the ore, the values specified below may be used for uranium and its daughters through radium-226, instead of those from paragraphs 1, 2, or 3 above.

[39 FR 23990]

a. For purposes of Table I, Col. 1—1×10^{-10} μCi/ml gross alpha activity; or 5×10^{-11} μCi/ml natural uranium; or 75 micrograms per cubic meter of air natural uranium.

b. For purposes of Table II, Col. 1—8×10^{-10} μCi/ml gross alpha activity; or 2×10^{-10} μCi/ml natural uranium; or 8 micrograms per cubic meter of air natural uranium.

[26 FR 11046]

5. For purposes of this Note, a radionuclide may be considered as not present in a mixture if (a) the ratio of the concentration of that radionuclide in the mixture (C_A) to the concentration limit for that radionuclide specified in Table II of Appendix B (MPC_A) does not exceed 1/10 (i.e. $\frac{C_A}{MPC_A}\leq\frac{1}{10}$) and (b) the sum of such ratios for all the radionuclides considered as not present in the mixture does not exceed 1/4 (i.e. $\frac{C_A}{MPC_A}+\frac{C_B}{MPC_B}+\ldots\ldots\leq\frac{1}{4}$).

APPENDIX C

Material	Microcuries
Americium-241	.01
Antimony-122	100
Antimony-124	10
Antimony-126	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-115	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	0.1
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-59	100
Nickel-63	10
Nickel-65	100
Niobium-93m	10
Niobium-95	10
Niobium-97	10
Osmium-185	10
Osmium-191m*	100
Osmium-191	100
Osmium-193	100
Palladium-103	100
Palladium-109	100
Phosphorus-32	10
Platinum-191	100
Platinum-193m	100
Platinum-193	100
Platinum-197m	100
Platinum-197	100
Plutonium-239	.01
Polonium-210	0.1
Potassium-42	10
Praseodymium-142	100
Praseodymium-143	100
Promethium-147	10
Promethium-149	10
Radium-226	.01
Rhenium-186	100
Rhenium-188	100
Rhodium-103m	100
Rhodium-105	100
Rubidium-86	10
Rubidium-87	10
Ruthenium-97	100
Ruthenium-103	10
Ruthenium-105	10
Ruthenium-106	1
Samarium-151	10
Samarium-153	100
Scandium-46	10
Scandium-47	100
Scandium-48	10
Selenium-75	10
Silicon-31	100
Silver-105	10
Silver-110m	1
Silver-111	100
Sodium-24	10
Strontium-85	10
Strontium-89	1
Strontium-90	0.1
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)[1]	100
Thulium-170	10
Thulium-171	10
Tin-113	10
Tin-125	10
Tungsten-181	10
Tungsten-185	10
Tungsten-187	100
**Uranium (natural)[2]	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

[35 FR 6475]

Note: For purposes of §§ 20.203 and 20.304, 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"). Example: For purposes of § 20.304, if a particular batch contains 20,000 μCi† of Au^{198} and 50,000 μCi† of C^{14}, it may also include not more than 300 μCi† of I^{131}. This limit was determined as follows:

$$\frac{20{,}000\ \mu Ci\ Au^{198}}{100{,}000\ \mu Ci} + \frac{50{,}000\ \mu Ci\ C^{14}}{100{,}000\ \mu Ci} + \frac{300\ \mu Ci\ I^{131}}{1{,}000\ \mu Ci} \leq 1$$

The denominator in each of the above ratios was obtained by multiplying the figure in the table by 1,000 as provided in § 20.304.

[1] Based on alpha disintegration rate of Th-232, Th 230 and their daughter products.

[2] Based on alpha disintegration rate of U-234, U-234, and U-235.

* Amended 36 FR 16898.

** Amended 39 FR 23990.

† Amended 38 FR 29314.

PART 20 • STANDARDS FOR PROTECTION AGAINST RADIATION

Appendix D

UNITED STATES NUCLEAR REGULATORY COMMISSION

INSPECTION AND ENFORCEMENT REGIONAL OFFICES

Region	Address	Telephone	
		Daytime	Nights and Holidays
I Connecticut, Delaware, District of Columbia, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont	Region I, USNRC Office of Inspection and Enforcement 631 Park Avenue King of Prussia, Pa. 19406	(215) 337-1150	(215) 337-1150
II Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, Panama Canal Zone, Puerto Rico, South Carolina, Tennessee, Virginia, Virgin Islands, and West Virginia	Region II, USNRC Office of Inspection and Enforcement 230 Peachtree St., N.W. Suite 1217 * Atlanta, Ga. 30303	* (404) 221-4503	* (404) 221-4503
III Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Ohio, and Wisconsin	Region III, USNRC Office of Inspection and Enforcement 799 Roosevelt Road Glen Ellyn, Ill. 60137	* (312) 858-2660	(312) 858-2660
IV Arkansas, Colorado, Idaho, Kansas, Louisiana, Montana, Nebraska, New Mexico, North Dakota, Oklahoma, South Dakota, Texas, Utah, and Wyoming	Region IV, USNRC Office of Inspection and Enforcement 611 Ryan Plaza Drive Suite 1000 Arlington, Texas 76012	(817)-334-2841	(817) 334-2841
V Alaska, Arizona, California, Hawaii, Nevada, Oregon, Washington, and U.S. territories and possessions in the Pacific	Region V, USNRC Office of Inspection and Enforcement 1990 N. California Blvd. Suite 202 Walnut Creek, Calif. 94596	(415) 486-3141	(415) 486-3141

40 FR 42557

*Amended 41 FR 55851.

NOTE: The reporting and record keeping requirements contained in §§ 20.205(b) and 20.205(c) and required by § 20.401(b) have been approved by GAO under B-180225 (R0054). The approval expires June 30, 1977.

Form NRC 3
(4-76)
10 CFR 19
10 CFR 20

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

NOTICE TO EMPLOYEES

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

NOTICE

A copy of Tele's AEC license, plus NRC Regulations and Tele's operating procedures are available to RADIATION WORKERS, and may be examined at the Health Physics Division Office. [Room 1134, Kline Bio. Twr.]

In Part 20 of its Rules and Regulations, the Nuclear Regulatory Commission has established standards for your protection against radiation hazards from radioactive material under license issued by the Nuclear Regulatory Commission. In Part 19 of its Rules and Regulations, the Nuclear Regulatory Commission has established certain provisions for the options of workers engaged in NRC licensed activities.

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.

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; and
7. Related matters.

REPORTS ON YOUR RADIATION EXPOSURE HISTORY

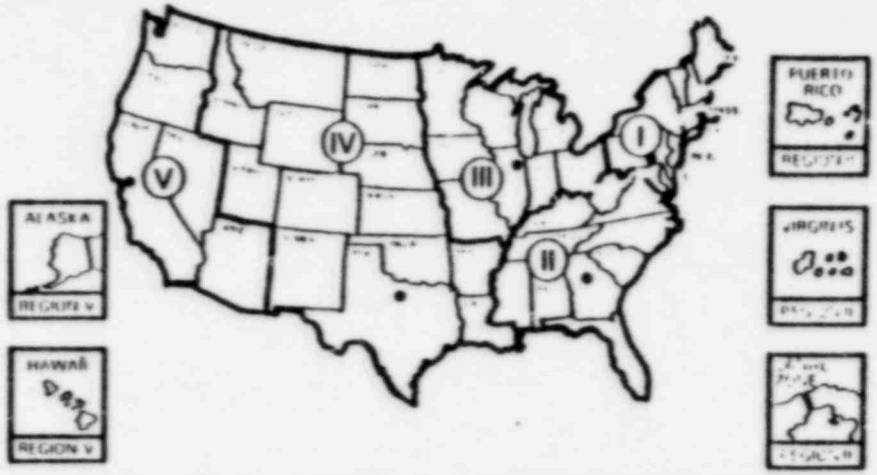
1. The NRC regulations require that your employer give you a written report if you receive an exposure in excess of any applicable limit as set forth in the regulations or in the license. The basic limits for exposure to employees are set forth in Sections 20.101, 20.103, and 20.104 of the Part 20 regulations. 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 regulations issued there under, 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 Inspection and Enforcement Regional Office (shown on map at right). 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.

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 working in or frequenting any portion of a restricted area to observe a copy on the way to or from their place of employment.



UNITED STATES NUCLEAR REGULATORY COMMISSION

Regional Offices

REGION	ADDRESS	TELEPHONE	
		DAYTIME	NIGHTS AND HOLIDAYS
I	Region I, Office of Inspection and Enforcement, USNRC 631 Park Avenue King of Prussia, Pennsylvania 19406	215 337-1180	215 337-1120
II	Region II, Office of Inspection and Enforcement, USNRC 230 Peachtree Street, N.W., Suite 818 Atlanta, Georgia 30303	404 526-4503	404 526-4503
III	Region III, Office of Inspection and Enforcement, USNRC 799 Roosevelt Road Glen Ellyn, Illinois 60137	312 858-2660	312 858-2660
IV	Region IV, Office of Inspection and Enforcement, USNRC 611 Ryan Plaza Drive, Suite 1000 Arlington, Texas 76012	817 334-2841	817 334-2841
V	Region V, Office of Inspection and Enforcement, USNRC 1990 N. California Boulevard, Suite 202, Walnut Creek Plaza Walnut Creek, California 94596	415 486-3141	415 486-3141

Appendix IV.

Appendix V.

CONTROL OF STUDENT EXPOSURE TO RADIATION

The following guides are recommended with respect to the uses of ionizing radiation in educational institutions and should be distributed to students participating in demonstrations and/or experiments involving radiation:

1. Persons in the general population at any age. Such individuals should not receive an exposure exceeding 0.5 rem per year in addition to natural background and medical exposures. This limit applies to those persons who are not occupational exposed. If an instructor or students of age 18 or greater is subjected routinely to work involving radiation, then he is an occupational worker and the exposure limit of 5 rem per year applies.

2. Persons under 18 years of age. These individuals shall not be occupationally exposed to radiation. Therefore, individuals under 18 years old should not be employed in an isotope laboratory.

3. Students under 18 years of age exposed during educational activities. Such individuals should not receive whole body exposure exceeding 0.1 rem per year due to their educational activity. To provide an additional factor of safety, it is recommended that each experiment be so planned that no individual receives more than 0.01 rem while conducting or participating in the experiment.

4. Students over 18 years of age exposed during educational activities fall into category 1 above.

It should be emphasized that there is no difficulty in performing radiation experiments and demonstrations in conformity with the above recommendations, if appropriate safeguards are provided.

The following precautions are recommended when radioisotopes are actually handled by the students:

PRECAUTIONARY PROCEDURES

1. "Good housekeeping" should be maintained at all times. Keep the laboratory neat; wash glassware regularly and do not let waste or contaminated material accumulate.

2. Perform a "mock" run, when practical, using stable or low-activity material to establish the adequacy of procedures and equipment for handling the radioactive material.

3. Measure and evaluate the radiation levels at hand and body locations prior to carrying out intended operations on a source of radioactive material.

4. Use a fume hood or glove box when performing operations that might produce air-borne contamination, (namely, evaporations. sanding or grinding operations, transfers of unsealed powdered material, etc.).

5. Wear protective gloves and a lab coat when performing operations that might result in hand or clothing contamination.

6. Survey skin, hair and clothing after handling unsealed radioactive material, and wash hands before leaving the laboratory.

7. Do not eat, drink or smoke in laboratories where unsealed radioactive material is handled, and do not store food in laboratory isotope storage refrigerators.

8. Do not pipette radioactive solutions by mouth.

9. Do not handle radioactive sources by hand unless you are certain that the contact dose is within permissible limits and that the source is not contaminated externally.

10. All containers of radioactive material should be properly labeled at all times. The label should indicate the date of assay and the kind and quantity of radioactive material, and should carry the standard yellow and magenta radioactivity symbol.

11. Containers of radioactive solutions shall be kept closed except when in actual use.

12. Radioactive sources shall be stored, when not in use, in a suitably labeled location with means to prevent unauthorized use. Adequate shielding should be provided.

13. Contact the Health Physics Division (6-2935 or 6-2936) in case of spillage or accident involving radiation.

Appendix VI.

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

Introduction

Yale University, through the University's Radiation Safety Committee, the University Health Services and the Health Physics Division, is striving to keep the radiation exposure of every employee as low as practicable. As a radiation worker, one may be exposed to more radiation than the general public. However, the United States Nuclear Regulatory Commission, (previously the United States Atomic Energy Commission) has established a basic exposure limit for all occupationally exposed adults of 5 rems per year. No clinical evidence of harm would be expected in an adult working with these levels for a lifetime. Because the risks of undesirable effects may be greater for young people, persons under 18 years of age are permitted to be exposed to only 10 percent of the adult occupational limits. (This lower limit is also applied to members of the general public). In the past, all employees' exposures have been below the 5 rem/year whole body exposure limit, prescribed by the Nuclear Regulatory Commission (NRC). Over ninety percent of radiation workers at Yale have been below 0.5 rem/year, 10% of the exposure limit.

The National Council on Radiation Protection and Measurements (NCRP) has recommended that because the developing fetus may be more sensitive to radiation than adults, the fetal radiation dose as a result of occupational exposure of the mother should not exceed 0.5 rem. According to the NCRP, particular efforts should be made to keep the radiation exposure of an embryo or fetus at the very lowest practicable level during the entire period of pregnancy.

Some recent studies have shown that the risk of leukemia and other cancers in children increases if the mother is exposed to a significant amount of radiation (greater than 1 rem) during pregnancy. Although other scientific studies have shown a much smaller effect from radiation, Yale wants the women employees to be aware of any possible risk so that the women can take steps they think appropriate to protect their offsprings.

Female employees working with radiation or radioactive materials must inform Yale, through the Health Physics Division, when a pregnancy has been confirmed or if pregnancy is contemplated. Upon notification, Yale will then do everything practicable to keep the fetal exposure below 0.5 rem during the pregnancy. The advice of the Health Physics Division should be obtained to determine whether radiation levels in your working areas are large enough that a fetus could receive 0.5 rem or more during the gestation period. If so, you should consider the following alternatives during your pregnancy:

1. Reducing your exposure, where possible, by decreasing the amount of time you spend in the radiation area, increasing your distance from the radiation source, and using shielding. Extreme care should be exercised when performing experiments or procedures where you might become contaminated. It is important to reduce the potential of an ingestion of radioactive materials during your pregnancy. Certain isotopes may cross the placental barrier and actually concentrate in the fetus.

2. Requesting your department head to reassign you to areas involving less exposure to radiation. If this is not possible, you might consider discussing a transfer within Yale with the Personnel Department, or leaving your job. If you decide to take such steps, do so without delay. The unborn child is most sensitive to radiation during the first three months of your pregnancy.

3. You may also, of course, choose to continue working in the higher radiation areas, but with full awareness that you are doing so at possibly some small increased risk for your unborn child.

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

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

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

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

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

If a pregancy is confirmed, contact the Health Physics Division (6-2935 or 6-2936) and assistance will be provided in establishing the expected dose to the fetus.

Discussion of Radiation

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

Many people receive additional radiation for medical reasons. The estimated average surface skin dose from one radiographic chest x-ray is 0.027 rem. The estimated average surface skin dose per abdominal x-ray is 0.62 rem.

Radiation can also be received from natural sources such as rock or brick structures, from consumer products such as television and glow-in-the-dark watches, and from air travel. The possible annual dose from working 8 hours a day near a granite wall at the Redcap Stand in Grand Central Station, New York City is 0.2 rem, and the average dose in the United States from TV, consumer products, and air travel is 0.003 rem.

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

Prenatal Irradiation

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

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

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

Summary

Occupational exposures to radiation are being kept low. However, qualified scientists have recommended that the radiation dose to a pregnant woman should not exceed 0.5 rem because of possible risks to her unborn child. Since this 0.5 rem is lower than the dose generally permitted to adult workers, women may want to take special actions to avoid receiving higher exposures, just as they might stop smoking during pregnancy or avoid taking unnecessary drugs to reduce possible risks to their unborn children. Contact the Health Physics Division (6-2935 or 6-2936) if there are questions.

Appendix VII.

LABORATORY PROCEDURES

Work Surfaces

All work areas (bench tops, hoods, floors, etc.) as well as storage areas adjacent to permanent set-ups and sinks should be covered at all times with stainless steel or plastic trays, or other impervious materials. For some purposes a plastic-backed absorbent peper will be satisfactory. However, if such paper is used, it should be discarded frequently to prevent spread of contamination.

Periodic Surveys of Radiation Areas

The immediate areas (namely hoods, bench tops and storage areas) in which radioactive materials are being used should be checked for contamination periodically by the radiation workers in that laboratory. In addition, these areas should be inspected each and every time there is reason to suspect a contamination incident.

Radioactive Contamination of Areas

In general, no radioactive contamination can be tolerated. Exceptions are, active work areas which will be clearly marked with the standard radiation caution signs or tape. Any contamination that is not confined to protected surfaces should be reported immediately to the Health Physics Division. The Health Physics Division will supervise the decontamination of such areas or equipment. The Health Physics Division considers 100 counts per minute above background on a liquid scintillation counter (approximately 100 picocuries per smear) to be a significant level of contamination.

Decontamination of Areas Contaminated with Radioactivity

Preparations for decontamination should begin promptly. Determine the extent of the contamination. The Health Physics Division will assist in this evaluation. The individual responsible for the contamination will perform the clean-up under the supervision of the Health Physics Division. The area or equipment should be considered contaminated until proven otherwise.

Decontamination of Personnel Contaminated with Radioactivity

Notify Principal Investigator immediately after contamination accident. Wash body area involved thoroughly for 2 or 3 minutes using only lukewarm water. If this procedure is not immediately and completely effective, notify the Health Physics Division.

Areosols, Dusts and Gaseous Products

Procedures involving aerosols, dusts or gaseous products, or procedures which might produce airborne contamination shall be conducted in a hood, glove box or other suitable closed system. All releases from such systems shall not exceed the maximum permissible concentration in air for the nuclide in question. See Appendix B, Table II. of 10CFR Part 20 for appropriate values (Appendix III.). However, where practical, traps should be incorporated in the experiment set-up to insure that environmental releases are as low as possible. Radioactive gases or materials with radioactive gaseous daughters must be stored in gas-tight containers and must be kept in areas having approved ventilation. Hoods to be used for radioisotope work should be tested by the Health Physics Division to insure that they meet the minimum requirements for air velocity at the face of the hood.

Appendix VII. (continued)

Iodine Vapors

Procedures in which iodine vapors may be generated shall be conducted in a glove box or isotope hood with adequate flow rate and charcoal filters. Advice should be sought from the Health Physics Division prior to conducting experiments with iodine and the facilities should be evaluated for containment purposes.

Appendix VIII.

RECOMMENDED PROCEDURES FOR

OPENING RADIOACTIVE SHIPMENTS

It is suggested that plastic gloves be worn while processing the received package.

1. Place package in vented hood, if available.

2. Wipe test package for removable contamination with filter paper and count for activity.

3. If the package contains gamma or high energy beta emitters, check dose rate on outside of package with survey meter.

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

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

6. Wipe test innermost container. Note: The liner, shield and isotope container may have surface contamination; they should be discarded as radioactive waste.

7. Record type of activity, quantity present in receiving log such as laboratory data book.

8. If contamination, leakage or variations in isotope, or quantity ordered are observed, notify the Health Physics Division.

Appendix IX.

LEAK TESTING OF SEALED SOURCES

Testing of Purchased and Fabricated Sealed Sources

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

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

1. Tests for leakage and/or contamination at intervals not to exceed six months.
2. Tests shall be capable of detecting the presence of 0.005 microcuries of removable contamination.
3. Test wipings shall be taken from the sealed source or from the surfaces of the device in which the sealed source is permanently or semi-permanently mounted or stored and on which one might expect contamination to accumulate and sent to the Health Physics Division for analysis.
4. Alpha sources shall be tested at intervals not to exceed three months.
5. Results of tests shall be recorded and maintained for inspection by NRC. If the required tests reveal the presence of 0.005 microcuries or more of removable contamination the Health Physics Division shall notify the Investigator and immediately withdraw the source from use, and shall cause it to be decontaminated and repaired or to be disposed of in accordance with the Radiation Safety Committee's regulations.

Exceptions to Leak Test Requirements

No leak tests required for the following:

1. Sealed sources containing tritium.
2. Sealed sources containing byproduct material with a half-life of less than thirty days.
3. Any sealed source, provided the quantity of byproduct material contained does not exceed ten times the quantity specified in Schedule B, Section 30.71,10CFR Part 30.

PART 30 • RULES OF GENERAL APPLICABILITY TO LICENSING--

§ 30.71 Schedule B.

Byproduct material	*Microcuries*
Antimony 122 (Sb 122)	100
Antimony 124 (Sb 124)	10
Antimony 125 (Sb 125)	10
Arsenic 73 (As 73)	100
Arsenic 74 (As 74)	10
Arsenic 76 (As 76)	10
Arsenic 77 (As 77)	100
Barium 131 (Ba 131)	10
**Barium-133 (Ba 133)	10
Barium 140 (Ba 140)	10
Bismuth 210 (Bi 210)	1
Bromine 82 (Br 82)	10
Cadmium 109 (Cd 109)	10
Cadmium 115m (Cd 115m)	10
Cadmium 115 (Cd 115)	100
Calcium 45 (Ca 45)	10
Calcium 47 (Ca 47)	10
Carbon 14 (C 14)	100
Cerium 141 (Ce 141)	100
Cerium 143 (Ce 143)	100
Cerium 144 (Ce 144)	1
Cesium 131 (Cs 131)	1,000
Cesium 134m (Cs 134m)	100
Cesium 134 (Cs 134)	1
Cesium 135 (Cs 135)	10
Cesium 136 (Cs 136)	10
Cesium 137 (Cs 137)	10
Chlorine 36 (Cl 36)	10
Chlorine 38 (Cl 38)	10
Chromium 51 (Cr 51)	1,000
Cobalt 58m (Co 58m)	10
Cobalt 58 (Co 58)	10
Cobalt 60 (Co 60)	1
Copper 64 (Cu 64)	100
Dysprosium 165 (Dy 165)	10
Dysprosium 166 (Dy 166)	100
Erbium 169 (Er 169)	100
Erbium 171 (Er 171)	100
Europium 152 9.2h (Eu 152 9.2h)	100
Europium 152 13 yr (Eu 152 13 yr)	1
Europium 154 (Eu 154)	1
Europium 155 (Eu 155)	10
Fluorine 18 (F 18)	1,000
Gadolinium 153 (Gd 153)	10
Gadolinium 159 (Gd 159)	100
Gallium 72 (Ga 72)	10
Germanium 71 (Ge 71)	100
Gold 198 (Au 198)	100
Gold 199 (Au 199)	100
Hafnium 181 (Hf 181)	10
Holmium 166 (Ho 166)	100
Hydrogen 3 (H 3)	1,000
Indium 113m (In 113m)	100
Indium 114m (In 114m)	10
Indium 115m (In 115m)	100
Indium 115 (In 115)	10
Iodine 125 (I 125)	1
Iodine 126 (I 126)	1
Iodine 129 (I 129)	0.1
Iodine 131 (I 131)	1
Iodine 132 (I 132)	10
Iodine 133 (I 133)	1
Iodine 134 (I 134)	10
Iodine 135 (I 135)	10
Iridium 192 (Ir 192)	10
Iridium 194 (Ir 194)	100
Iron 55 (Fe 55)	100
Iron 59 (Fe 59)	10
Krypton 85 (Kr 85)	100
Krypton 87 (Kr 87)	10
Lanthanum 140 (La 140)	10
Lutetium 177 (Lu 177)	100
Manganese 52 (Mn 52)	10
Manganese 54 (Mn 54)	10
Manganese 56 (Mn 56)	10
Mercury 197m (Hg 197m)	100
Mercury 197 (Hg 197)	100
Mercury 203 (Hg 203)	10
Molybdenum 99 (Mo 99)	100
Neodymium 147 (Nd 147)	100
Neodymium 149 (Nd 149)	100
Nickel 59 (Ni 59)	100
Nickel 63 (Ni 63)	10
Nickel 65 (Ni 65)	100
Niobium 93m (Nb 93m)	10
Niobium 95 (Nb 95)	10
Niobium 97 (Nb 97)	10
Osmium 185 (Os 185)	10
Osmium 191m (Os 191m)	100
Osmium 191 (Os 191)	100
Osmium 193 (Os 193)	100
Palladium 103 (Pd 103)	100
Palladium 109 (Pd 109)	100
Phosphorus 32 (P 32)	10
Platinum 191 (Pt 191)	100
Platinum 193m (Pt 193m)	100
Platinum 193 (Pt 193)	100
Platinum 197m (Pt 197m)	100
Platinum 197 (Pt 197)	100
Polonium 210 (Po 210)	0.1
Potassium 42 (K 42)	10
Praseodymium 142 (Pr 142)	100
Praseodymium 143 (Pr 143)	100
Promethium 147 (Pm 147)	10
Promethium 149 (Pm 149)	10
Rhenium 186 (Re 186)	100
Rhenium 188 (Re 188)	100
Rhodium 103m (Rh 103m)	100
Rhodium 105 (Rh 105)	100
Rubidium 86 (Rb 86)	10
Rubidium 87 (Rb 87)	10
Ruthenium 97 (Ru 97)	100
Ruthenium 103 (Ru 103)	10
Ruthenium 105 (Ru 105)	10
Ruthenium 106 (Ru 106)	1
Samarium 151 (Sm 151)	10
Samarium 153 (Sm 153)	100
Scandium 46 (Sc 46)	10
Scandium 47 (Sc 47)	100
Scandium 48 (Sc 48)	10
Selenium 75 (Se 75)	10
Silicon 31 (Si 31)	100
Silver 105 (Ag 105)	10
Silver 110m (Ag 110m)	1
Silver 111 (Ag 111)	100
Sodium 24 (Na 24)	10
Strontium 85 (Sr 85)	10
Strontium 89 (Sr 89)	1
Strontium 90 (Sr 90)	0.1
Strontium 91 (Sr 91)	10
Strontium 92 (Sr 92)	10
Sulphur 35 (S 35)	100
Tantalum 182 (Ta 182)	10
Technetium 96 (Tc 96)	10
Technetium 97m (Tc 97m)	100
Technetium 97 (Tc 97)	100
Technetium 99m (Tc 99m)	100
Technetium 99 (Tc 99)	10
Tellurium 125m (Te 125m)	10
Tellurium 127m (Te 127m)	10
Tellurium 127 (Te 127)	100
Tellurium 129m (Te 129m)	10
Tellurium 129 (Te 129)	100
Tellurium 131m (Te 131m)	10
Tellurium 132 (Te 132)	10
Terbium 160 (Tb 160)	10
Thallium 200 (Tl 200)	100
Thallium 201 (Tl 201)	100
Thallium 202 (Tl 202)	100
Thallium 204 (Tl 204)	10
Thulium 170 (Tm 170)	10
Thulium 171 (Tm 171)	10
Tin 113 (Sn 113)	10
Tin 125 (Sn 125)	10
Tungsten 181 (W 181)	10
Tungsten 185 (W 185)	10
Tungsten 187 (W 187)	100
Vanadium 48 (V 48)	10
Xenon 131m (Xe 131m)	1,000
Xenon 133 (Xe 133)	100
Xenon 135 (Xe 135)	100
Ytterbium 175 (Yb 175)	100
Yttrium 90 (Y 90)	10
Yttrium 91 (Y 91)	10
Yttrium 92 (Y 92)	100
Yttrium 93 (Y 93)	100
Zinc 65 (Zn 65)	10
Zinc 69m (Zn 69m)	100
Zinc 69 (Zn 69)	1,000
Zirconium 93 (Zr 93)	10
Zirconium 95 (Zr 95)	10
Zirconium 97 (Zr 97)	10
Any byproduct material not listed above other than alpha emitting byproduct material	0.1

** Added 36 FR 16898.

Appendix X.

YALE UNIVERSITY
EMERGENCY PROCEDURES

Emergency Telephone Numbers
Health Physics Division
6-2935 or 6-2936
Campus Police 121 or 6-8341
Yale-New Haven Hospital
Emergency Room 6-1960

FOR ACCIDENTS INVOLVING RADIATION EXPOSURE OR RADIOACTIVE MATERIAL

I. Emergency Notification

A. Extreme Hazards - high radiation levels or the possibility of airborne contamination from dry or volatile radioactive materials.

1. Evacuate the laboratory immediately; close and lock the door and/or stand guard to prevent entrance; during normal working hours, immediately contact the Health Physics Division and give details of the accident.

2. During off hours, evacuate laboratory, close door, call Campus Police and give details of the accident and await instructions. The Campus Police will contact Health Physics Division personnel. Health Physics Division personnel will then contact the individual and give instructions.

3. If you have to leave the area to call Health Physics Division or Campus Police, cover your shoes if you suspect contamination and do not touch anything unnecessarily.

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

B. Accident Involving Both Personnel Injury and Radioactive Contamination

1. Give first aid, if necessary. If the wound appears to be superficial, flush with cool water immediately.

2. During normal working hours contact Campus Police first and then the Health Physics Division. Give details of the accident and await instructions. Health Physics Division personnel will contact the individual and give instructions.

3. Remove any contaminated clothing and if necessary wrap the individual in a fire blanket.

4. If it is necessary to send individuals to the Emergency Room at Yale-New Haven Hospital, inform the Emergency Room that a contaminated patient is coming. Campus Police must provide transportation.

5. Keep all uninjured personnel involved close to the accident area. Prevent the spread of contamination by isolating and sealing the accident area. Keep people out. Shut down ventilation if possible.

C. Other Hazards

1. Accidents involving both radioactive material and infectious viruses.

   Deactivate the virus and notify the Health Physics Division or during off hours Campus Police and await instruction.

2. Fires, explosions, etc.

   Evacuate all personnel immediately, sound the fire alarm, notify the Health Physics Division or Campus Police and await instruction; do not leave the area or general vicinity without first being monitored for radioactive contamination.

D. For All Emergencies Use the Following Guides

Keep calm, use common sense, protect people, do not spread contamination. Always assume you are contaminated until a survey shows otherwise, call Health Physics Division or Campus Police and await instruction.

1. Confine Contamination

   a. Localize the spill. Right a tipped container, drop absorbent material on the spill, damp down a dry spill. Always wear gloves when working with a spill.

   b. Do not track contamination about the laboratory. Call, do not go, for help if possible. Prevent others from entering the immediate contamination area.

   c. Close doors and where possible adjust ventilation to prevent the spread of airborne contamination.

   d. Check your shoes before leaving the area of a cleaned-up spill.

2. Protect Personnel

   a. Remove contaminated clothing and gently wash contaminated parts of the body with detergent.

   b. Be especially thorough in flushing out wounds with cool water.

   c. Hold your breath if airborne contamination is suspected or until you leave the area.

   d. Warn other workers.

II. Campus Police Procedures

A. The Campus Police upon receiving a call should collect the following information: the location of the accident, the number of injured and/or exposed persons, the types and approximate quantity of radioactive material involved, and the name and telephone number of the individual giving the information.

B. The Campus Police, after receiving a report of a radiation accident and dispatching a policeman to the scene, should contact:

1. If injuries are involved, the Hospital Emergency Room either to warn of an accident or indicate that contaminated patients are coming.

2. Health Physics Division:

Start at the top of the list and proceed down until someone is reached. The individual reached should obtain the facts, contact Mrs. Mulvaney, give her the information and proceed to the accident scene if necessary. Mrs. Mulvaney will contact others and either dispatch them to Yale or give further instructions.

Health Physics Division	Yale Phone Number	Home Phone
George R. Holeman, Director	6-0570 or 6-2935	453-5520
Kenneth W. Price, Health Physicist	6-0570 or 6-2935	248-2543
Frederick Greenhalgh, " "	6-0570 or 6-2935	248-8845
George Andrews, Chief Technician	6-0536	387-5392
M. Claire Mulvaney, Sr.Admin.Asst.	6-0570 or 6-2935	248-2553

University Radiation Safety Committee

Dr. Peter D. Parker	6-2320 or 6-3347	288-5374

C. Campus Police when reaching the scene of the accident should help determine if injured personnel need emergency care or not; if so, they should provide transportation (either patrol car or ambulance). Anyone known to be contaminated should be wrapped in a fire blanket or other means used to contain the contamination. Call Emergency Room, Yale-New Haven Hospital and indicate the number of patients coming.

D. Campus Police should not leave the Emergency Room until they and their automobile, or ambulance, have been checked either by Yale Health Physics Division, or the Hospital Radiation Safety Officer.

III. Accident Reporting

All released to the public of information concerning accidents involving radiation shall be released through Dr. Peter D. Parker (6-2320), Chairman of the Yale Radiation Safety Committee to the Yale Public Relations representative, S. A. Kezerian (6-3440).

Appendix XI.

THE NATIONAL COUNCIL ON RADIATION PROTECTION AND MEASUREMENTS REPORTS

Report Number	Title	Price
8	Control and Removal of Radioactive Contamination in Laboratories (1951).....	$ 2.00
9	Recommendations for Waste Disposal of Phosphorus-32 and Iodine-131 for Medical Users (1951).....	$ 2.00
10	Radiological Monitoring Methods and Instruments (1952).	$ 2.00
12	Recommendations for the Disposal of Carbon-14 Wastes (1953.....	$ 2.00
14	Protection Against Betatron-Synchrotron Radiations Up to 100 Million Electron Volts (1954).....	$ 2.00
16	Radioactive Waste Disposal in the Ocean (1954).....	$ 2.00
22	Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air and in Water for Occupational Exposure (1959).....	$ 2.00
23	Measurement of Neutron Flux and Spectra for Physical and Biological Applications (1960).....	$ 2.00
25	Measurement of Absorbed Dose of Neutrons and of Mixtures of Neutrons and Gamma Rays (1961).....	$ 2.00
27	Stopping Powers for Use with Cavity Chambers (1961)....	$ 2.00
28	A Manual of Radioactivity Procedures (1961).....	$ 3.00
30	Safe Handling of Radioactive Materials (1964).....	$ 2.00
31	Shielding for High-Energy Electron Accelerator Installations (1964).....	$ 2.00
32	Radiation Protection in Educational Institutions (1966)	$ 3.00
33	Medical X-Ray and Gamma-Ray Protection for Energies Up to 10 MeV - Equipment Design and Use (1968).....	$ 3.00
34	Medical X-Ray and Gamma-Ray Protection for Energies Up to 10 MeV - Structural Shielding Design and Evaluation (1970).....	$ 4.00
35	Dental X-Ray Protection (1970).....	$ 4.00
36	Radiation Protection in Veterinary Medicine (1970).....	$ 4.00
37	Precautions in the Management of Patients Who Have Received Therapeutic Amounts of Radionuclides (1970)..	$ 4.00
38	Protection Against Neutron Radiation (1971).....	$ 5.00

Appendix XI. (continued)

39	Basic Radiation Protection Criteria (1971).....	$ 4.00
40	Protection Against Radiation From Brachytherapy Sources (1972).....	$ 4.00
41	Specification of Gamma-Ray Brachytherapy Sources (1974)...	$ 3.00
42	Radiological Factors Affecting Decision-Making in a Nuclear Attack (1974).....	$ 4.00
43	Review of the Current State of Radiation Protection Philosophy (1975).....	$ 3.00
44	Krypton-85 in the Atmosphere - Accumulation, Biological Significance, and Control Technology (1975).....	$ 4.00
45	Natural Background Radiation in the United States (1975)..	$ 5.00
46	Alpha-Emitting Particles in Lungs (1975).....	$ 3.00
47	Tritium Measurement Techniques (1976).....	$ 4.50
48	Radiation Protection for Medical and Allied Health Personnel (1976).....	$ 4.50

[All prices subject to change without notice]

Reports may be obtained from:

NCRP Publication

P.O. Box 30175

Washington, D.C. 20014