Rules of

Department of Health and Senior Services

Division 20—Division of Environmental Health and Epidemiology

Chapter 10—Protection Against Ionizing Radiation

Title 19—DEPARTMENT OF HEALTH AND SENIOR SERVICES
Division 20—Division of Environmental Health and Epidemiology
Chapter 10—Protection Against Ionizing Radiation

19 CSR 20-10.010 Definitions Relating to Ionizing Radiation

PURPOSE: This rule defines technical terms which are used throughout this chapter.

PUBLISHER'S NOTE: The secretary of state has determined that the publication of the entire text of the material which is incorporated by reference as a portion of this rule would be unduly cumbersome or expensive. Therefore, the material which is so incorporated is on file with the agency who filed this rule, and with the Office of the Secretary of State. Any interested person may view this material at either agency's headquarters or the same will be made available at the Office of the Secretary of State at a cost not to exceed actual cost of copy reproduction. The entire text of the rule is printed here. This note refers only to the incorporated by reference material.

(1) Absorbed dose of any ionizing radiation is the energy imparted to matter by ionizing particles per unit mass of irradiated material at the place of interest. The unit of absorbed dose is the rad.

(2) Aluminum equivalent is the thickness of aluminum affording the same attenuation, under specified conditions, as the material in question.

(3) Controlled area is an area in which the occupational exposure of personnel to radiation or to radioactive material is under the supervision of an individual in charge of radiation protection. (This means that a controlled area is one that requires control of access, occupancy and working conditions for radiation protection purposes.)

(4) Dead-man switch is a switch so constructed that a circuit-closing contact can only be maintained by continuous pressure by the operator.

(5) Department is the Missouri Department of Health.

(6) Dose, unless otherwise indicated, as used in these rules, means rem dose.

(7) Effective half-life (T), in days, is—

$$T = \frac{(T_b) \times (T_r)}{(T_b) + (T_r)}$$

where T_b = biological half-life in days; and
where T_r = physical half-life in days.

(8) Excessive radiation dose is a dose of radiation in excess of the maximum permissible dose (19 CSR 20-10.040).

(9) Individual is any human being.

(10) Installation is a place containing one (1) or more sources of radiation.

(11) Lead equivalent is the thickness of lead affording the same attenuation, under specified conditions, as the material in question.

(12) Maximum permissible accumulated dose (MPAD) is the dose of radiation which, if accumulated during the lifetime of the individual, is not expected to cause observable bodily injury.

(13) Maximum permissible dose (MPD) is the maximum rem dose that the body of an individual or specific parts of the body shall be permitted to receive in a stated period of time.

(14) Person is any individual, partnership, association, corporation, firm, trust, estate, public or private institution, group, agency, political subdivision of this state and any legal successor, representative, agent or agency of them.

(15) Personnel monitoring is the determination of the radiation dose received by an individual during the specified period.

(16) Protective barrier is a barrier of attenuating materials used to reduce radiation exposure.

(17) Qualified expert is an individual fitted by training and experience to perform dependable radiation surveys, to oversee radiation monitoring and to estimate the degree of radiation hazard. If the ability of a qualified expert is questioned, the department shall be the judge of his/her qualifications, in regard to which it may consider the testimony of other persons whom it deems expert.

(18) Rad is the unit of absorbed dose and is equal to one hundred (100) ergs per gram. It is a measure of the energy imparted to matter by ionizing particles per unit mass of irradiated material at the place of interest.

(19) Radiation is gamma rays and X-rays, alpha and beta particles, high-speed electrons, neutrons, protons, other nuclear particles and any other ionizing radiation, but not sound or radio waves or visible, infrared or ultraviolet light.

(20) Radiation hazard is any condition that might result in the exposure of individuals to excessive radiation dose.

(21) Radiation machine is any device that produces radiation when in operation.

(22) Radioactive material is any material, solid, liquid or gas, that emits radiation spontaneously.

(23) Relative biological effectiveness (RBE) is a numerical factor which is used to compare the effectiveness of absorbed dose of radiation delivered in different ways. The standard of comparison is X-ray or gamma radiation having a linear energy transfer in water of three (3) kev per micron. A list of RBE values of various kinds of radiation is given in Table 1, 19 CSR 20-10.110.

(24) Rem is equal to the absorbed dose in rads multiplied by the appropriate RBE.

(25) Roentgen is a unit of exposure dose of X-ray or gamma radiation such that the associated corpuscular emission per 0.001293 gram of air produces, in air, ions carrying one (1) esu of quantity of electricity.

(26) Sealed source is a quantity of radioactive material so enclosed as to prevent the escape of any radioactive material.

(27) Source (of radiation) is a radiation machine or a quantity of radioactive materials.

(28) Survey is the evaluation of actual or potential radiation or contamination hazards by or under the supervision of a qualified expert.

(29) X-ray tube housing protective diagnostic-type is one that reduces the leakage radiation to a maximum of 0.10 roentgen in one (1) hour at a distance of one (1) meter from the tube target when the X-ray tube is operating at its maximum current and voltage.

(30) X-ray tube housing protective therapeutic-type is a tube housing so constructed that the leakage radiation at a distance of one (1) meter from the target cannot exceed the rate of one (1) roentgen per hour and at a distance

of five centimeters (5 cm) from any point on the surface of the housing accessible to the patient cannot exceed the rate of thirty (30) roentgens per hour when the tube is operated at its maximum current and voltage.

(31) Useful beam is that part of radiation which passes through the window, aperture, cone or collimating device of the tube housing.

(32) User is a person having administrative control over one (1) or more sources.

(33) Other scientific and technical terms not specifically defined in this rule shall be used in accordance with the definitions in recommendations of the National Committee on Radiation Protection and Measurements as published in *Handbooks of the National Bureau of Standards* or the American Standard Association's *Glossary of Terms in Nuclear Science and Technology*, with preference being in the order given.

AUTHORITY: section 192.420, RSMo 1986. This rule was previously filed as 13 CSR 50-90.010. Original rule filed Nov. 9, 1964, effective Dec. 9, 1964.*

**Original authority: 192.420, RSMo 1963.*

19 CSR 20-10.020 Exemptions from Requirements of this Chapter

PURPOSE: This rule lists exemptions from the requirements of this chapter. It avoids unnecessary regulation and duplication of regulatory authority.

(1) The following materials, machines and conditions are exempt from the requirements of this chapter:

(A) Timepieces, instruments, novelties or devices containing self-luminous elements themselves. These timepieces, instruments, novelties or devices shall not be exempt if they are stored, used or handled in a quantity or fashion that an individual might receive a radiation dose exceeding the limits established in 19 CSR 20-10.040;

(B) Electrical equipment that produces radiation incidental to its operation for other purposes, providing the dose rate to the whole body at the point of nearest approach to this equipment when any external shielding is removed does not exceed 0.5 rem per year. The production testing or factory servicing of this equipment shall not be exempt;

(C) Radiation machines which cannot be used in a manner as to produce radiation (for example, X-ray machines or electrical equipment in storage or transport);

(D) Radioactive material being transported across a state in conformance with regulations of any federal agency having jurisdiction over safety in interstate transport;

(E) The use of radioactive sources licensed by the United States Nuclear Regulatory Commission to installations in Missouri; and

(F) Other sources of radiation that the department finds should be exempted as approved by the Committee on Radiation Control.

AUTHORITY: section 192.420, RSMo 1986. This rule was previously filed as 13 CSR 50-90.020. Original rule filed Nov. 9, 1964, effective Dec. 9, 1964.*

**Original authority: 192.420, RSMo 1963.*

19 CSR 20-10.030 Registration of Sources of Ionizing Radiation

PURPOSE: This rule states the conditions under which sources of ionizing radiation must be registered with the department.

(1) The owner, user or operator of every existing not exempted source shall register the source of radiation with the department within ninety (90) days (March 9, 1965) after the effective date of this rule (December 9, 1964) and once every two (2) years after that as long as s/he continues to possess the source. Any newly acquired source shall be registered with the Department of Health within thirty (30) days after receipt. The registration shall be submitted on a form available from the department and shall describe each source, its location and use and the waste disposal practices, if any. The registration also shall give the name and address of the user(s) and the name and address of the qualified expert.

(2) The user shall notify the department in writing within thirty (30) days of any change with respect to his/her radiation sources which may substantially increase or decrease the potential for personnel exposure.

(3) All nonexempt radiation sources brought into Missouri for temporary use must be registered at least four (4) days before entry. The registration shall indicate the type and amount of the source, the scope of the use, duration of use and the exact locations of the use or storage. This requirement may be waived at the discretion of the Department of Health if the use is an unexpected occurrence of major consequence demanding immediate use and of which it would not have been possible to have knowledge four (4) days in advance.

(4) An installation registration may be issued, on application, for research institutions, teaching institutions and certain manufacturing establishments whose radiation conditions are undergoing constant change. These institutions and manufacturing establishments must maintain an active and effective radiation committee to review and approve all uses of radiation sources. A qualified expert must be retained to make hazard evaluations of all uses of all radiation sources and must be given authority to enforce recommended procedures.

(5) Registration shall not imply the department's approval of the conditions described in the registration.

AUTHORITY: section 192.420, RSMo 1986. This rule was previously filed as 13 CSR 50-90.030. Original rule filed Nov. 9, 1964, effective Dec. 9, 1964.*

**Original authority: 192.420, RSMo 1963.*

19 CSR 20-10.040 Maximum Permissible Exposure Limits

PURPOSE: This rule establishes maximum permissible exposure limits. Maximum permissible doses are established for both external and internal exposures for persons within or outside controlled areas.

(1) Except as provided in subsections (1)(A)–(C) of this rule, the maximum permissible dose (MPD) from all external sources of ionizing radiation for persons within a controlled area shall be as listed in Table I.

Table I

Part of Body	A Maximum dose permitted in any calendar year	B Maximum dose permitted in any calendar quarter
Whole body, head and trunk, major portion of the bone marrow, gonads or lens of eye.	5 rems	3 rems
Skin of large body area.	30 rems	10 rems
Hands and forearms, feet and ankles	75 rems	25 rems

A dose to the whole body, head and trunk, in addition to that listed in Table I, shall be permitted for a calendar year, provided that all three (3) of the following conditions are met:

(A) During any calendar quarter, the maximum dose of three (3) rems, listed in Column B of Table I, is not exceeded;
(B) The user has determined the individual's previous accumulated occupational dose; and
(C) The dose, when added to the previously accumulated occupational dose, does not exceed the maximum permissible accumulated dose (MPAD) calculated according to the formula: MPAD = (N–18) × 5 rems, where N is the individual's age in full years.

(2) For persons within a controlled area, the radiation dose to the tissues of the body from radioactive materials within the body shall be controlled by limiting the average rates at which these materials are taken into the body. Where this intake results from breathing contaminated air, the concentrations of the radionuclides in the air, averaged over any calendar quarter, shall not exceed the concentrations listed in Appendix I, Table 2,Column 1 of this chapter. The values in this table are for a workweek of forty (40) hours. For longer workweeks, the values must be adjusted downward accordingly. Where this intake results from the occurrence of radioactive material in drinking water and foodstuffs, the permissible concentrations shall be the same as in section (3) of this rule.

(3) For persons outside a controlled area, the MPD to the whole body due to sources within the controlled area or to radioactive materials escaping from the controlled area, shall be two (2) millirems in any one (1) hour, 0.1 rem in any seven (7) consecutive days and 0.5 rem in any year. In meeting this requirement, the user may take reasonable advantage of operational factors such as the amount of time that the radiation is present or that the area is occupied by any one (1) person.

(4) For persons outside a controlled area, the radiation dose to tissues of the body from radioactive materials within the body shall be controlled by limiting the average rates at which the materials are taken into the body. Where this intake results from the occurrence of radioactive materials in the air, drinking water or foodstuffs, the average concentrations of the radionuclides in the air or drinking water or foodstuffs, averaged over any calendar quarter, shall not exceed the concentrations listed in Appendix I, Table 2, Columns 2 and 3 of this chapter.

AUTHORITY: section 192.420, RSMo 1986. This rule was previously filed as 13 CSR 50-90.040. Original rule filed Nov. 9, 1964, effective Dec. 9, 1964.*

**Original authority: 192.420, RSMo 1963.*

19 CSR 20-10.050 Personnel Monitoring and Radiation Surveys

PURPOSE: This rule lists requirements for personnel monitoring and radiation surveys. Conditions under which routine monitoring of individuals occupationally exposed to radiation shall not be required are also listed.

(1) The user shall provide for radiation surveys and monitoring sufficient to assure compliance with other rules of this chapter. The radiation survey and monitoring shall be performed by, or under the direction of, a qualified expert using suitable instruments and methods for measuring radiation.

(2) Until an actual radiation survey can be performed, a written statement made by a qualified expert based on his/her analysis of the situation shall be acceptable as evidence of the absence of radiation hazard in a given area.

(3) Personnel monitoring shall be required for each individual for whom there is any reasonable possibility of receiving a weekly dose of all radiation exceeding fifty (50) millirems, taking into consideration the use of protective gloves, aprons or other radiation-limiting devices.

(4) Routine monitoring of individuals occupationally exposed to radiation from radiation machines shall not be required if—
(A) A qualified expert has specified the operating conditions under which there is no reasonable chance that any individual will be subjected to a dose of either more than twenty-five (25) millirems in any seven (7) consecutive days or more than three hundred twenty-five (325) millirems in any thirteen (13) consecutive weeks;
(B) The operating conditions in subsection (4)(A) of this rule are made known to all individuals who may be occupationally exposed to the radiation; and
(C) The installation continues to operate only under the specified conditions.

(5) Radiation surveys of sealed sources and sealed storage areas shall be made at least semiannually to insure the integrity of the containment. The survey shall be capable of detecting the presence of 0.005 microcurie of removable contamination. If the survey reveals the presence of 0.005 microcurie or more of removable contamination, the user shall immediately withdraw the sealed source from use and shall cause it to be decontaminated and repaired, or disposed of, in accordance with procedures established by a qualified expert.

AUTHORITY: section 192.420, RSMo 1986. This rule was previously filed as 13 CSR 50-90.050. Original rule filed Nov. 9, 1964, effective Dec. 9, 1964.*

**Original authority: 194.420, RSMo 1963.*

19 CSR 20-10.060 Radiation Exposure Records and Reports

PURPOSE: This rule requires the user of radiation sources to keep records of personnel exposures, radiation measurements and the receipt and disposal of radioactive materials. It also states the conditions under which personnel exposures and radiation incidents must be reported.

(1) Records of all measurements required by 19 CSR 20-10.050 shall be kept available by the user for inspection by a representative of the department. Personnel monitoring records shall include the Social Security number and date of birth of the individual concerned.

(2) An accurate accounting for all radioactive materials, not specifically exempted by 19 CSR 20-10.020, shall be maintained. The records shall show the amount of radioactive material received, transferred, decayed in storage and disposed of and other information as may be necessary to account for the difference between the amount of radioactive material received or produced and the amount on hand. The user shall also keep records of the release of radioactive materials to the environs sufficient to demonstrate compliance with other rules of this chapter. The records shall be maintained and made available for inspection for at least five (5) years after final disposition of the radioactive material.

(3) Upon termination of employment of an individual, the individual or department, or both, upon request, shall be supplied with a summary statement of that individual's radiation dose. (The estimated maximum dose shall be stated if no personnel monitoring has been carried out.) This record shall include statements of any circumstances where the dose to the employee from any source of radiation exceeded those specified in this chapter. Employee records must be kept available for inspection by the department during the tenure of employment of an employee and for a period of five (5) years after that.

(4) When it is known or believed that an accidental dose to a person in the installation may have exceeded two (2) times the amount permitted by applicable sections of 19 CSR20-10.040, all facts relative to the occurrence shall be reported in detail to the department within seven (7) days of the discovery of the facts, and a copy of the report shall be put in that individual's personnel file. The cause of the overexposure shall immediately be sought out and corrected.

(5) The loss or theft of any source of radiation not exempt from these rules shall be reported immediately to the department by telephone and a written report shall be submitted within twenty-four (24) hours.

(6) At the request of any employee, each user shall advise the employee annually of the employee's exposure to radiation as shown in records maintained by the user.

(7) Any accident involving either a public or private carrier conveying radioactive material shall be reported immediately to the Department of Health by telephone and a written report shall be submitted within twenty-four (24) hours.

AUTHORITY: section 192.420, RSMo 1986. This rule was previously filed as 13 CSR 50-90.060. Original rule filed Nov. 9, 1964, effective Dec. 9, 1964.*

**Original authority: 192.420, RSMo 1963.*

19 CSR 20-10.070 Storage of Radioactive Materials

PURPOSE: This rule requires the safe storage of radioactive material.

(1) The user shall see that radioactive materials are kept in a manner that will provide reasonable assurance that, during routine access to a controlled area, no person will be exposed in excess of the limits set forth in 19 CSR 20-10.040. Provisions shall be made to minimize the hazard to emergency workers in the event of fire and in situations where earthquake, flood and windstorm potentials exist.

(2) The user shall see that vaults or rooms used for storing materials that may emit radioactive gases or airborne particulate matter are ventilated in a manner that the concentration of the gases or particulate matter in the air does not constitute a radiation hazard.

(3) When there is a reasonable possibility that chemical, radiation or other action might lead to leakage of radioactive material from a container, the user shall provide a secondary tray or catchment to the container adequate to retain the entire amount of radioactive material.

AUTHORITY: section 192.420, RSMo 1986. This rule was previously filed as 13 CSR 50-90.070. Original rule filed Nov. 9, 1964, effective Dec. 9, 1964.*

**Original authority: 192.420, RSMo 1963.*

19 CSR 20-10.080 Control of Radioactive Contamination

PURPOSE: This rule limits personnel exposure by requiring the control or removal of radioactive contamination.

(1) The user shall see that all work with radioactive materials is carried out under conditions which will minimize the possibility of spread of radioactive material that could result in the exposure of any person above any limit specified in 19 CSR 20-10.040.

(2) Where the nature of work is such that a person or his/her clothing may become contaminated with radioactive material, both shall be monitored according to procedures established by a qualified expert. Personal contamination shall be removed according to procedures established by a qualified expert.

(3) Clothing or other material contaminated to a degree which could result in the exposure of any person above any limit specified in 19 CSR 20-10.040 should be retained inside the installation until it can be decontaminated or disposed of according to procedures established by a qualified expert.

AUTHORITY: section 192.420, RSMo 1986. This rule was previously filed as 13 CSR 50-90.080. Original rule filed Nov. 9, 1964, effective Dec. 9, 1964.*

**Original authority: 192.420, RSMo 1963.*

19 CSR 20-10.090 Disposal of Radioactive Wastes

PURPOSE: This rule lists the conditions under which radioactive material may be released into the air or water or may be disposed of by burial in soil or discharged into a sanitary sewer.

(1) No user shall release radioactive material into the air or water in a manner which causes exposure of any person above the limits specified in 19 CSR 20-10.040. If several users are discharging radioactive wastes to the same environs, they shall cooperate in limiting the release and shall file with the Department of Health a statement of their agreed *pro rata* releases.

(2) Every person who receives radioactive waste material for holding and preparation, prior to disposal, shall first obtain a permit from the Department of Health for the holding and preparation.

(3) No owner or user shall dispose of radioactive waste materials by dumping or burial in soil except at sites approved by and registered with the Department of Health.

(4) Radioactive material may be discharged into a sanitary sewer provided that the—

(A) Material is readily soluble or dispersible in water;

(B) Quantity of any radioactive material released into the sewer in any one (1) day, when diluted by the average daily quantity of sewerage released into the sewer by the owner or user, will not result in average concentration exceeding the limits specified in Table 2, Appendix I of this chapter; and

(C) Gross quantity of all radioactive material so discharged does not exceed one (1) curie per year.

AUTHORITY: section 192.420, RSMo 1986. This rule was previously filed as 13 CSR 50-90.090. Original rule filed Nov. 9, 1964, effective Dec. 9, 1964.*

**Original authority: 192.420, RSMo 1963.*

19 CSR 20-10.100 Radiation Labeling

PURPOSE: This rule establishes requirements for labeling radiation machines, radiation areas and containers in which radioactive materials are transferred, stored or used and to list exemptions from posting or labeling requirements.

(1) The user shall indicate the presence of radiation by posting conspicuous signs or labels which bear appropriate wording, as described in sections (5)–(10) of this rule to explain the nature of the hazard.

(2) All such radiation warning signs and labels shall bear the standard symbol for designating any radiation hazard as described in Appendix II of this chapter.

(3) The use of the standard symbol, signs or labels for any other purpose is expressly prohibited. The symbol, signs and labels and the lettering used with it shall be as large as practical, consistent with size of the equipment or material. The lettering shall not be superimposed on the symbol.

(4) All signs and labels required by this section shall use the conventional radiation colors (magenta or purple and yellow background) and bear a conventional radiation symbol.

(5) All radiation machines shall be clearly labeled as follows: "Caution: Radiation This Equipment Produces Radiation When Energized." (Labels should be placed on the control panel near the switch which energizes the tube.)

(6) Each area shall be designated as a radiation area and shall be conspicuously posted with a sign(s) bearing a radiation caution symbol and the words "Caution: Radiation Area" if radiation levels exist which could subject an individual, continuously present, to five (5) millirems within any one (1) hour or could result in a dose of one hundred (100) millirems in any seven (7) consecutive days.

(7) Each radiation area where there exists a radiation level in excess of one hundred (100) milliroentgens per hour shall be conspicuously posted with a sign(s) bearing a conventional radiation caution symbol and the words "Caution: High Radiation Area."

(A) Each high radiation area, except those containing only therapeutic units operating at sixty (60) kilovolts peak (kvp) or below or diagnostic units or both, shall be equipped with an internal control circuit which shall either cause the radiation exposure rate to be reduced to below one hundred (100) milliroentgens per hour upon entry of an individual into the area or shall energize a conspicuous visible or audible alarm signal in a manner that the individual entering and the supervisor of the activity are made aware of the entry. In the case of a temporary high radiation area (thirty (30) days or less), a control circuit is not required if a barricade, such as a fence or rope is erected and the required caution signs are posted.

(8) Any room, enclosure or operating area in which airborne radioactive materials exist in excess of the amount as stated in Table 2, Column 3, Appendix I of this chapter shall be conspicuously posted with a sign(s) bearing a conventional radiation symbol and the words "Caution: Airborne Radioactivity Area." In the event that respiratory protection is required, the equipment prescribed shall also be conspicuously designated.

(9) Each entrance to an area or to rooms shall be conspicuously posted with a sign(s) bearing a conventional radiation symbol and the words "Caution: Radioactive Material" if the radioactive material used or stored is an amount exceeding ten (10) times the maximum exempted amount as specified in Table 1, Appendix I of this chapter.

(10) Each container in which radioactive material is transferred, stored or used shall bear a conventional symbol and the words "Caution: Radioactive Material." Labeling shall not be required if the concentration of radioactive material does not exceed that specified in Table 2, Column 2 or 3, Appendix I if the quantity of radioactive material does not exceed that in Table 1, Appendix I of this chapter or for laboratory containers being used transiently. Where practical, signs required by this section should describe the quantities and kinds of radioactive materials involved.

(11) All areas that are readily accessible, but not normally occupied, and where a radiation hazard may exist on a frequent or infrequent basis, shall be suitably restricted and posted with the accepted radiation-hazard label.

(12) All radiation-hazard labels posted shall be removed when the source of radiation is no longer present.

(13) Notwithstanding the provisions of other sections of this rule—

(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 (12") from the surface of the device does not exceed five (5) milliroentgens per hour and the sealed source is properly labeled in accordance with the requirements of this rule.

(B) Rooms or other areas in hospitals are not required to be posted with caution signs because of the presence of patients containing radioactive material provided that attendant personnel are adequately instructed as to the precautions necessary to prevent the exposure of any individual to radiation or airborne radioactive materials in excess of the limits established in 19 CSR 20-10.

(C) Caution signs are not required to be posted at areas or rooms containing radioactive materials for periods of less than twenty-four (24) hours provided that these materials are constantly attended by an individual during these periods, or that there is no chance that any individual would come into the area or room not knowing a hazard exists.

(D) Radiation areas and high radiation areas which result from the operation of therapeutic X-ray machines operated at potentials of sixty (60) kvp and below or from the operation of diagnostic X-ray machines shall be exempt from the posting requirements of this rule provided that the operator of the equipment has taken precautions to insure that no individual other than the patient shall be in the radiation area.

AUTHORITY: section 192.420, RSMo 1986. This rule was previously filed as 13 CSR 50-90.100. Original rule filed Nov. 9, 1964, effective Dec. 9, 1964.*

**Original authority: 192.420, RSMo 1963.*

19 CSR 20-10.110 Relative Biological Effectiveness Values

PURPOSE: This rule lists relative biological effectiveness values which are referred to in other rules of 19 CSR 20-10.

(1) The relative biological effectiveness (RBE) values in Table I are convenient approximations to relate dose in rads to dose in rems. The value will vary greatly with the biological effect being considered, the acuteness of the exposure and many other factors. The qualified expert should evaluate these factors for each situation and should adjust the values accordingly.

Table I—RBE Values

Radiation	RBE
X-rays and gamma rays of all energies and electrons and beta rays above 0.03 Million electron Volts (MEV)	1.0
Fast neutrons and protons up to 10 MeV	10
Alpha particles	10
Heavy recoil nuclei	20

AUTHORITY: section 192.420, RSMo 1986. This rule was previously filed as 13 CSR 50-90.110. Original rule filed Nov. 9, 1964, effective Dec. 9, 1964.*

**Original authority: 192.420, RSMo 1963.*

19 CSR 20-10.120 General Requirements for Diagnostic X-ray Equipment

PURPOSE: This rule establishes general requirements for diagnostic X-ray equipment.

(1) The X-ray tube housing shall be of the protective diagnostic type.

(2) Total filtration shall be as follows:
(A) For fluoroscopic and radiographic equipment operating at seventy (70) kilovolts peak (kvp) and below, the total filtration permanently in the useful beam, for routine use, shall be equivalent to at least 1.5 millimeters (mm) of aluminum. This condition shall be considered fulfilled if the half value layer (HVL) of the useful beam is 1.5 mm of aluminum or greater.
(B) For fluoroscopic and radiographic equipment capable of operating above seventy (70) kvp, the total filtration permanently in the useful beam shall be equivalent to at least 2.5 mm of aluminum. This condition shall be considered fulfilled if the HVL of the useful beam is 2.5 mm of aluminum or greater.

(3) The exposure switch for routine diagnostic X-rays or routine diagnostic fluoroscopy shall be of the dead-man type or time limiting switch acceptable to the department.

(4) Diaphragms or cones shall be used for collimating the useful beam and shall provide the same degree of protection as the tube housing.

AUTHORITY: section 192.420, RSMo 1986. This rule was previously filed as 13 CSR 50-90.120. Original rule file Nov. 9, 1964, effective Dec. 9, 1964.*

**Original authority: 192.420, RSMo 1963.*

19 CSR 20-10.130 Special Requirements for Medical Fluoroscopic Installations

PURPOSE: This rule establishes special requirements for medical fluoroscopic installations.

(1) All fluoroscopes shall be so constructed that the entire cross-section of the useful beam is attenuated by a primary barrier. Collimators and adjustable diaphragms or shutters shall be provided to restrict the size of the useful beam to less than the area of the barrier. For conventional fluoroscopes, this requirement is met if, when the adjustable diaphragm is open to its fullest extent, an unilluminated two centimeter (2 cm) margin is left on the fluorescent screen with the screen centered in the beam at a distance of thirty-five centimeters (35 cm) (fourteen inches (14")) from the panel or table top. The margin requirement does not apply to installations where image amplifiers are used but a protective shield shall be provided in these installations so that the useful beam does not produce a radiation hazard.

(2) Accessory shielding devices (such as cones, curtains, bucky slot covers, shielding between patient and fluoroscopist) shall be used as required to reduce the exposure dose rate to not more than fifty (50) milliroentgens per hour in the area adjacent to the machine normally occupied by the fluoroscopist and his/her assistants during fluoroscopy.

(3) The target to panel distance shall not be less than eighteen inches (18").

(4) A manually reset cumulative timing device shall be used which will either indicate elapsed time by an audible signal or turn off the apparatus when the total exposure exceeds a predetermined limit given in one (1) or a series of exposures. The device shall have a maximum range of five (5) minutes.

(5) The primary beam barrier should have a lead equivalent of at least 2.0 millimeters (mm) and shall not be less than 1.5 mm for one hundred (100) kvp, should be at least 2.4 mm and shall be not less than 1.8 mm for one hundred twenty-five (125) kvp, and should be at least 2.7 mm and shall be not less than 2.0 mm for one hundred fifty (150) kvp. For conventional fluoroscopes, this requirement may be assumed to have been met if the exposure-dose rate measured at the viewing surface of the fluorescent screen does not exceed fifty (50) milliroentgens per hour with the screen in the primary beam of the fluoroscope without a patient, under normal operating conditions.

(6) Collimators and adjustable diaphragms or shutters to restrict the size of the useful beam shall provide a minimum of 2.0 mm lead equivalent protection for one hundred (100) kvp, 2.4 mm for one hundred twenty-five (125) kvp and 2.7 mm for one hundred fifty (150) kvp.

(7) For routine fluoroscopy, the dose rate measured at the panel or table top shall not exceed six (6) roentgens per minute.

(8) Mobile fluoroscopic equipment shall meet the requirements of sections (1)–(7) of this rule except that—
(A) In the absence of panel or table top, a cone or spacer frame hall limit the target-to-skin distance to not less than twelve inches (12");
(B) It shall be impossible to operate the machine when the collimating cone or diaphragm is not in place; and
(C) The maximum permissible exposure-dose rate of six (6) roentgens per minute shall be measured at the minimum target-to-skin distance.

AUTHORITY: section 192.420, RSMo 1986. This rule was previously filed as 13 CSR 50-90.130. Original rule filed Nov. 9, 1964, effective Dec. 9, 1964.*

**Original authority: 192.420, RSMo 1963.*

19 CSR 20-10.140 Special Requirements for Medical Radiographic Installations

PURPOSE: This rule establishes special requirements for medical radiographic X-ray installations.

(1) A device shall be provided to terminate the exposure after a preset time or exposure.

(2) The exposure switch shall be so arranged that it cannot be conveniently operated outside a shielded area. Exposure switches for spot film devices used in conjunction with fluoroscopic tables are excepted from this requirement.

AUTHORITY: section 192.420, RSMo 1986. This rule was previously filed as 13 CSR 50-90.140. Original rule filed Nov. 9, 1964, effective Dec. 9, 1964.*

**Original authority: 192.420, RSMo 1963.*

19 CSR 20-10.150 Special Requirements for Dental Radiographic Installations

PURPOSE: This rule establishes special requirements for dental radiographic installations.

(1) The diameter of the useful beam at the cone tip should be not more than 2.75 inches and shall be not more than three inches (3") for routine intraoral radiography.

(2) A device shall be provided to terminate the exposure after a preset time or exposure.

(3) The exposure control switch shall be provided with a cord sufficiently long so that the operator can stand at least six feet (6') from the tube housing for all exposures and well away from the useful beam.

AUTHORITY: section 192.420, RSMo 1986. This rule was previously filed as 13 CSR 50-90.150. Original rule filed Nov. 9, 1964, effective Dec. 9, 1964.*

**Original authority: 192.420, RSMo 1963.*

19 CSR 20-10.160 Special Requirements for Mobile Medical Radiographic Installations

PURPOSE: This rule establishes special requirements for mobile medical radiographic installations.

(1) All mobile equipment shall be provided with cones or frames so that the minimum target-to-skin distance is at least eighteen inches (18").

(2) The exposure control switch shall be so arranged that the operator can stand at least six feet (6') from the patient and outside the primary beam for all exposures.

(3) A device shall be provided to terminate the exposure after a preset time.

AUTHORITY: section 192.420, RSMo 1986. This rule was previously filed as 13 CSR 50-90.160. Original rule filed Nov. 9, 1964, effective Dec. 9, 1964.*

**Original authority: 192.420, RSMo 1963.*

19 CSR 20-10.170 Special Requirements for Photofluorographic Installations

PURPOSE: This rule establishes special requirements for photofluorographic installations.

(1) A collimator shall restrict the useful beam to the area of the fluorographic screen.

(2) The exposure switch shall be so arranged that it cannot be conveniently operated outside a shielded area. Exposure switches for spot film devices used in conjunction with fluoroscopic tables are exempted from this requirement.

(3) A device shall be provided to terminate the exposure after a preset time or exposure.

(4) Output of the photofluorographic installation shall not exceed one (1) roentgen per exposure at the panel.

AUTHORITY: section 192.420, RSMo 1986. This rule was previously filed as 13 CSR 50-90.170. Original rule filed Nov. 9, 1964, effective Dec. 9, 1964.*

**Original authority: 192.420, RSMo 1963.*

19 CSR 20-10.180 Requirements for Radiation Therapy Installations

PURPOSE: This rule establishes requirements for radiation therapy installations.

(1) The radiation source housing shall be a protective therapeutic type.

(2) Permanent diaphragms or cones shall be used for collimating the useful beam and shall afford the same degree of protection as the radiation source housing. Adjustable or removable beam-defining devices shall not transmit more than five percent (5%) of the useful beam obtained at the maximum kilovoltage and with the maximum treatment filter.

(3) The filter system shall be so arranged as to permit proper filter selection and alignment. Filters shall be secured in place to prevent them from dropping out during treatment. The filter slot shall be so constructed that the radiation escaping through it does not exceed one (1) roentgen per hour at one (1) meter.

(4) The radiation source shall be centered and mounted so that it cannot turn or slide with respect to the aperture when the source is in the on position.

(5) Means shall be provided to immobilize the radiation source during stationary radiation treatment.

(6) A timer shall be provided to terminate the exposure after a preset time.

(7) With equipment operating above sixty (60) kilovolts peak (kvp), interlocks shall be provided so that when any door to the treatment room is opened, either the machine will be shut off automatically or the radiation level within the room will be reduced to an average of not more than two (2) milliroentgens per hour and a maximum of ten (10) milliroentgens per hour at a distance of one (1) meter in any direction from the target. After this shutoff or reduction in output, it shall be possible to restore the machine to full operation only from the control panel.

(8) The control shall be located outside of the treatment room or within a protective booth.

(9) Equipment utilizing shutters to control the useful beam shall have a shutter position indicator on the control panel.

(10) There shall be on the control panel some easily discernible device which will give positive information as to whether or not the source of the ionizing radiation is in the on position.

AUTHORITY: section 192.420, RSMo 1986. This rule was previously filed as 13 CSR 50-90.180. Original rule filed Nov. 9, 1964, effective Dec. 9, 1964.*

**Original authority: 192.420, RSMo 1963.*

19 CSR 20-10.190 Requirements for Room Shielding

PURPOSE: This rule provides necessary information regarding requirements for room shielding for diagnostic and therapeutic installations.

(1) The requirements for room shielding shall conform to the requirements defined in the various handbooks published by the United States Department of Commerce and National Bureau of Standards.

AUTHORITY: section 192.420, RSMo 1986. This rule was previously filed as 13 CSR 50-90.190. Original rule filed Nov. 9, 1964, effective Dec. 9, 1964.*

**Original authority: 192.420, RSMo 1963.*

19 CSR 20-10.200 Shoe-Fitting Devices

PURPOSE: This rule prohibits the use of radiation for the purpose of selling footwear.

(1) It shall be unlawful for any person, partnership, association or corporation to operate or maintain within this state, any fitting devices or machines which use fluoroscopic, X-ray or radiation principles for the purpose of selling footwear through commercial outlets.

AUTHORITY: section 192.420, RSMo 1986. This rule was previously filed as 13 CSR 50-90.200. Original rule filed Nov. 9, 1964, effective Dec. 9, 1964.*

**Original authority: 192.420, RSMo 1963.*

APPENDIX I

Table 1

Exempt Quantities of Radioisotopes

	Column 1 Unsealed Sources (Microcuries)	Column 2 Sealed Sources (Microcuries)
Actinium 227	0.1	1
Americium 241	0.1	1
Antimony 124	1	10
Arsenic 73	10	100
74	10	100
76	10	100
77	10	100
Astatine 211	0.1	10
Barium—Lanthanum 140	1	10
Beryllium 7	100	1000
Bromine 82	10	100
Cadmium-Silver 109	10	100
Calcium 45	1	10
Carbon 14	1000	10000
Cerium-Praseodymium 144	1	10
Cesium-Barium 137	10	100
Chlorine 36	10	100
Chromium 51	100	1000
Cobalt 58	10	100
60	10	100
Copper 64	10	100
Curium 242	0.1	1
Europium 154	1	10
Fluorine 18	100	1000
Gallium 72	10	100
Germanium 71	100	1000
Gold 196	10	100
198	10	100
199	10	100
Holmium 166	10	100
Hydrogen-3 (Tritium)	1000	10000
Indium 114	1	10
Iodine 131	1	10
132	10	100
Iridium 190	10	100
192	10	100
Iron 55	10	100
59	1	10
Krypton 85	1000	10000
Lanthanum 140	10	100
Lead 203	10	100
210 + dtrs	0.1	1
Lutecium 177	10	100
Manganese 52	10	100
54	10	100
56	10	100
Molybdenum 99	10	100
Nickel 59	10	100
63	10	100
Niobium 95	10	100
Palladium-Silver 109	10	100
Palladium-Rhodium 103	10	100
Phosphorus 32	10	100
Platinum 191	10	100
193	10	100
Plutonium 239	0.1	1
Polonium 210	0.1	1
Potassium 42	10	100
Praseodymium 143	10	100
Promethium 147	10	100
Radium 226	0.1	1
Rhenium 183	10	100
186	10	100
Rhodium 105	10	100
Rubidium 86	10	100
Ruthenium 103	10	100
Ruthenium-Rhodium 106	1	10
Samarium 151	1	10
153	10	100
Scandium 46	10	100
47	10	100
48	10	100
Silver 105	10	100
110	10	100
111	10	100
Sodium 22	10	100
24	10	100
Strontium 89	1	10
Strontium-Yttrium 90	0.1	1.0
Sulfur 35	10	100
Tantalum 182	10	100
Technetium 96	1	10
99	1	10
Tellurium 127	10	100
129	10	100
Thallium 200	10	100
201	100	1000
202	10	100
204	10	100
Thorium nat.	100	1000
Thorium-Protoactinium 234	1	10
Thulium-Ytterbium 170	1	10
Tin 113	10	100
Tungsten 181	10	100
185	10	100
Uranium 233	0.1	1
natural	1000	10000
Vanadium 48	10	100
Yttrium 91	1	10
Zinc 65	10	100
Zirconium Niobium 95	10	100

Table 2

Concentrations in Water and Air Above Natural Background

Element (atomic number)	Isotope[1]		Column 1 Air (uc/ml)	Column 2 Water (uc/ml)	Column 3 Air (uc/ml)
Actinium (89)	Ac 227	S	2×10^{-12}	2×10^{-6}	8×10^{-14}
		I	3×10^{-11}	3×10^{-4}	9×10^{-13}
	Ac 228	S	8×10^{-8}	9×10^{-5}	3×10^{-9}
		I	2×10^{-8}	9×10^{-5}	6×10^{-10}
Americium (95)	Am 241	S	6×10^{-12}	4×10^{-6}	2×10^{-13}
		I	1×10^{-10}	2×10^{-4}	4×10^{-12}
	Am 243	S	6×10^{-12}	4×10^{-6}	2×10^{-13}
		I	1×10^{-10}	3×10^{-5}	4×10^{-12}
Antimony (51)	Sb 122	S	2×10^{-7}	3×10^{-5}	6×10^{-9}
		I	1×10^{-7}	3×10^{-5}	5×10^{-9}
	Sb 124	S	2×10^{-7}	2×10^{-5}	5×10^{-9}
		I	2×10^{-8}	2×10^{-5}	7×10^{-10}
	Sb 125	S	5×10^{-7}	1×10^{-4}	2×10^{-8}
		I	3×10^{-8}	1×10^{-4}	9×10^{-10}
Argon[2] (18)	A 37	Sub	6×10^{-3}	—	1×10^{-4}
	A 41	Sub	2×10^{-6}	—	4×10^{-8}
Arsenic (33)	As 73	S	2×10^{-6}	5×10^{-4}	7×10^{-8}
		I	4×10^{-7}	5×10^{-4}	1×10^{-8}
	As 74	S	3×10^{-7}	5×10^{-5}	1×10^{-8}
		I	1×10^{-7}	5×10^{-5}	4×10^{-9}
	As 76	S	1×10^{-7}	2×10^{-5}	4×10^{-9}
		I	1×10^{-7}	2×10^{-5}	3×10^{-9}
	As 77	S	5×10^{-7}	8×10^{-5}	2×10^{-8}
		I	4×10^{-7}	8×10^{-5}	1×10^{-8}
Astatine (85)	At 211	S	7×10^{-9}	2×10^{-6}	2×10^{-10}
		I	3×10^{-8}	7×10^{-5}	1×10^{-9}
Barium (56)	Ba 131	S	1×10^{-6}	2×10^{-4}	4×10^{-8}
		I	4×10^{-7}	2×10^{-4}	1×10^{-8}
	Ba 140	S	1×10^{-7}	3×10^{-5}	4×10^{-9}
		I	4×10^{-8}	2×10^{-5}	1×10^{-9}
Berkelium (97)	Bk 249	S	9×10^{-10}	6×10^{-4}	3×10^{-11}
		I	1×10^{-7}	6×10^{-4}	4×10^{-9}
Beryllium (4)	Be 7	S	6×10^{-6}	2×10^{-3}	2×10^{-7}
		I	1×10^{-6}	2×10^{-3}	4×10^{-8}
Bismuth (83)	Bi 206	S	2×10^{-7}	4×10^{-5}	6×10^{-9}
		I	1×10^{-7}	4×10^{-5}	5×10^{-9}
	Bi 207	S	2×10^{-7}	6×10^{-5}	6×10^{-9}
		I	1×10^{-8}	6×10^{-5}	5×10^{-10}
	Bi 210	S	6×10^{-9}	4×10^{-5}	2×10^{-10}
		I	6×10^{-9}	4×10^{-5}	2×10^{-10}
	Bi 212	S	1×10^{-7}	4×10^{-4}	3×10^{-9}
		I	2×10^{-7}	4×10^{-4}	7×10^{-9}
Bromine (35)	Br 82	S	1×10^{-6}	3×10^{-4}	4×10^{-8}
		I	2×10^{-7}	4×10^{-5}	6×10^{-9}
Cadmium (48)	Cd 109	S	5×10^{-8}	2×10^{-4}	2×10^{-9}
		I	7×10^{-8}	2×10^{-4}	3×10^{-9}
	Cd 115m	S	4×10^{-8}	3×10^{-5}	1×10^{-9}
		I	4×10^{-8}	3×10^{-5}	1×10^{-9}
	Cd 115	S	2×10^{-7}	3×10^{-5}	8×10^{-9}
		I	2×10^{-7}	4×10^{-5}	6×10^{-9}
Calcium (20)	Ca 45	S	3×10^{-8}	9×10^{-6}	1×10^{-9}
		I	1×10^{-7}	2×10^{-4}	4×10^{-9}
	Ca 47	S	2×10^{-7}	5×10^{-5}	6×10^{-9}
		I	2×10^{-7}	3×10^{-5}	6×10^{-9}
Californium (98)	Cf 249	S	2×10^{-12}	4×10^{-6}	5×10^{-14}
		I	1×10^{-10}	2×10^{-5}	3×10^{-12}
	Cf 250	S	5×10^{-12}	1×10^{-5}	2×10^{-13}
		I	1×10^{-10}	3×10^{-5}	3×10^{-12}
	Cf 252	S	6×10^{-12}	7×10^{-6}	2×10^{-13}
		I	1×10^{-10}	2×10^{-5}	4×10^{-12}
Carbon (6)	C 14	S	4×10^{-6}	8×10^{-4}	1×10^{-7}
	(CO_2)	Sub	5×10^{-5}	—	1×10^{-6}
Cerium (58)	Ce 141	S	4×10^{-7}	9×10^{-5}	2×10^{-8}
		I	2×10^{-7}	9×10^{-5}	5×10^{-9}
	Ce 143	S	3×10^{-7}	4×10^{-5}	9×10^{-9}
		I	2×10^{-7}	4×10^{-5}	7×10^{-9}
	Ce 144	S	1×10^{-8}	1×10^{-5}	3×10^{-10}
		I	6×10^{-9}	1×10^{-5}	2×10^{-10}
Cesium (55)	Cs 131	S	1×10^{-5}	2×10^{-4}	4×10^{-7}
		I	3×10^{-6}	9×10^{-4}	1×10^{-7}
	Cs 134m	S	4×10^{-5}	6×10^{-3}	1×10^{-6}
		I	6×10^{-6}	1×10^{-3}	2×10^{-7}
	Cs 134	S	4×10^{-8}	9×10^{-6}	1×10^{-9}
		I	1×10^{-8}	4×10^{-5}	4×10^{-10}
	Cs 135	S	5×10^{-7}	1×10^{-4}	2×10^{-8}
		I	9×10^{-8}	2×10^{-4}	3×10^{-9}
	Cs 136	S	4×10^{-7}	9×10^{-5}	1×10^{-8}
		I	2×10^{-7}	6×10^{-5}	6×10^{-9}
	Cs 137	S	6×10^{-8}	2×10^{-5}	2×10^{-9}
		I	1×10^{-8}	4×10^{-5}	5×10^{-10}
Chlorine (17)	Cl 36	S	4×10^{-7}	8×10^{-5}	1×10^{-8}
		I	2×10^{-8}	6×10^{-5}	8×10^{-10}
	Cl 38	S	3×10^{-6}	4×10^{-4}	9×10^{-8}
		I	2×10^{-6}	4×10^{-4}	7×10^{-8}
Chromium (24)	Cr 51	S	1×10^{-5}	2×10^{-3}	4×10^{-7}
		I	2×10^{-6}	2×10^{-3}	8×10^{-8}
Cobalt (27)	Co 57	S	3×10^{-6}	5×10^{-4}	1×10^{-7}
		I	2×10^{-7}	4×10^{-4}	6×10^{-9}
	Co 58m	S	2×10^{-5}	3×10^{-3}	6×10^{-7}
		I	9×10^{-6}	2×10^{-3}	3×10^{-7}
	Co 58	S	8×10^{-7}	1×10^{-4}	3×10^{-8}
		I	5×10^{-8}	9×10^{-5}	2×10^{-9}
	Co 60	S	3×10^{-7}	5×10^{-5}	1×10^{-8}
		I	9×10^{-9}	3×10^{-5}	3×10^{-10}
Copper (29)	Cu 64	S	2×10^{-6}	3×10^{-4}	7×10^{-8}
		I	1×10^{-6}	2×10^{-4}	4×10^{-8}
Curium (96)	Cm 242	S	1×10^{-10}	2×10^{-5}	4×10^{-12}
		I	2×10^{-10}	3×10^{-5}	6×10^{-12}
	Cm 243	S	6×10^{-12}	5×10^{-6}	2×10^{-13}
		I	1×10^{-10}	2×10^{-5}	3×10^{-12}
	Cm 244	S	9×10^{-12}	7×10^{-6}	3×10^{-13}
		I	1×10^{-10}	3×10^{-5}	3×10^{-12}
	Cm 245	S	5×10^{-12}	4×10^{-6}	2×10^{-13}
		I	1×10^{-10}	3×10^{-5}	4×10^{-12}
	Cm 246	S	5×10^{-12}	4×10^{-6}	2×10^{-13}
		I	1×10^{-10}	3×10^{-5}	4×10^{-12}
Dysprosium (66)	Dy 165	S	3×10^{-6}	4×10^{-4}	9×10^{-8}
		I	2×10^{-6}	4×10^{-4}	7×10^{-8}
	Dy 166	S	2×10^{-7}	4×10^{-5}	8×10^{-9}
		I	2×10^{-7}	4×10^{-5}	7×10^{-9}
Erbium (68)	Er 169	S	6×10^{-7}	9×10^{-5}	2×10^{-8}
		I	4×10^{-7}	9×10^{-5}	1×10^{-8}
	Er 171	S	7×10^{-7}	1×10^{-4}	2×10^{-8}
		I	6×10^{-7}	1×10^{-4}	2×10^{-8}
Europium (63)	Eu 152 (TV/2= 9.2 hrs)	S	4×10^{-7}	6×10^{-5}	1×10^{-8}
		I	3×10^{-7}	6×10^{-5}	1×10^{-8}
	Eu 152 (TV/2= 13 yrs)	S	1×10^{-8}	8×10^{-5}	4×10^{-10}
		I	2×10^{-8}	8×10^{-5}	6×10^{-10}
	Eu 154	S	4×10^{-9}	2×10^{-5}	1×10^{-10}
		I	7×10^{-9}	2×10^{-5}	2×10^{-10}
	Eu 155	S	9×10^{-8}	2×10^{-4}	3×10^{-9}
		I	7×10^{-8}	2×10^{-4}	3×10^{-9}
Fluorine (9)	F 18	S	5×10^{-6}	8×10^{-4}	2×10^{-7}
		I	3×10^{-6}	5×10^{-4}	9×10^{-8}
Gadolinium (64)	Gd 153	S	2×10^{-7}	2×10^{-4}	8×10^{-9}
		I	9×10^{-8}	2×10^{-4}	3×10^{-9}
	Gd 159	S	5×10^{-7}	8×10^{-5}	2×10^{-8}
		I	4×10^{-7}	8×10^{-5}	1×10^{-8}
Gallium (31)	Ga 72	S	2×10^{-7}	4×10^{-5}	8×10^{-9}
		I	2×10^{-7}	4×10^{-5}	6×10^{-9}
Germanium (32)	Ge 71	S	1×10^{-5}	2×10^{-3}	4×10^{-7}
		I	6×10^{-6}	2×10^{-3}	2×10^{-7}
Gold (79)	Au 196	S	1×10^{-6}	2×10^{-4}	4×10^{-8}
		I	6×10^{-7}	1×10^{-4}	2×10^{-8}
	Au 198	S	3×10^{-7}	5×10^{-5}	1×10^{-8}
		I	2×10^{-7}	5×10^{-5}	8×10^{-9}
	Au 199	S	1×10^{-6}	2×10^{-4}	4×10^{-8}
		I	8×10^{-7}	2×10^{-4}	3×10^{-8}
Hafnium (72)	Hf 181	S	4×10^{-8}	7×10^{-5}	1×10^{-9}
		I	7×10^{-8}	7×10^{-5}	3×10^{-9}
Holmium (67)	Ho 166	S	2×10^{-7}	3×10^{-5}	7×10^{-9}
		I	2×10^{-7}	3×10^{-5}	6×10^{-9}
Hydrogen (1)	H 3	S	5×10^{-6}	3×10^{-3}	2×10^{-7}
		Sub	2×10^{-3}	—	4×10^{-5}
Indium (49)	In 113m	S	8×10^{-6}	1×10^{-3}	3×10^{-7}
		I	7×10^{-6}	1×10^{-3}	2×10^{-7}
	In 114m	S	1×10^{-7}	2×10^{-5}	4×10^{-9}
		I	2×10^{-8}	2×10^{-5}	7×10^{-10}
	In 115m	S	2×10^{-6}	4×10^{-4}	8×10^{-8}
		I	2×10^{-6}	4×10^{-4}	6×10^{-8}
	In 115	S	2×10^{-7}	9×10^{-5}	9×10^{-9}
		I	3×10^{-8}	9×10^{-5}	1×10^{-9}
Iodine (53)	I 126	S	8×10^{-9}	2×10^{-6}	3×10^{-10}
		I	3×10^{-7}	9×10^{-5}	1×10^{-8}
	I 129	S	2×10^{-9}	4×10^{-7}	6×10^{-11}
		I	7×10^{-8}	2×10^{-4}	2×10^{-9}
	I 131	S	9×10^{-9}	2×10^{-6}	3×10^{-10}
		I	3×10^{-7}	6×10^{-5}	1×10^{-8}
	I 132	S	2×10^{-7}	6×10^{-5}	8×10^{-9}
		I	9×10^{-7}	2×10^{-4}	3×10^{-8}
	I 133	S	3×10^{-8}	7×10^{-6}	1×10^{-9}
		I	2×10^{-7}	4×10^{-5}	7×10^{-9}
	I 134	S	5×10^{-7}	1×10^{-4}	2×10^{-8}
		I	3×10^{-6}	6×10^{-4}	1×10^{-7}
	I 135	S	1×10^{-7}	2×10^{-5}	4×10^{-9}
		I	4×10^{-7}	7×10^{-5}	1×10^{-8}
Iradium (77)	Ir 190	S	1×10^{-6}	2×10^{-4}	4×10^{-8}
		I	4×10^{-7}	2×10^{-4}	1×10^{-8}
	Ir 192	S	1×10^{-7}	1×10^{-5}	4×10^{-9}
		I	3×10^{-8}	4×10^{-5}	9×10^{-10}
	Ir 194	S	2×10^{-7}	3×10^{-5}	8×10^{-9}
		I	2×10^{-7}	3×10^{-5}	5×10^{-9}
Iron (26)	Fe 55	S	9×10^{-7}	8×10^{-4}	3×10^{-8}
		I	1×10^{-6}	2×10^{-3}	3×10^{-8}
	Fe 59	S	1×10^{-7}	6×10^{-5}	5×10^{-9}
		I	5×10^{-8}	5×10^{-5}	2×10^{-9}
Krypton[2] (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}
Lanthanum (57)	La 140	S	2×10^{-7}	2×10^{-5}	5×10^{-9}
		I	1×10^{-7}	2×10^{-5}	4×10^{-9}
Lead (82)	Pb 203	S	3×10^{-6}	4×10^{-4}	9×10^{-8}
		I	2×10^{-6}	4×10^{-4}	6×10^{-8}
	Pb 210	S	1×10^{-10}	1×10^{-7}	4×10^{-12}
		I	2×10^{-10}	2×10^{-4}	8×10^{-12}
	Pb 212	S	2×10^{-8}	2×10^{-5}	6×10^{-10}
		I	2×10^{-8}	2×10^{-5}	7×10^{-10}
Lutecium (71)	Lu 177	S	6×10^{-7}	1×10^{-4}	2×10^{-8}
		I	5×10^{-7}	1×10^{-4}	2×10^{-8}
Manganese (25)	Mn 52	S	2×10^{-7}	3×10^{-5}	7×10^{-9}
		I	1×10^{-7}	3×10^{-5}	5×10^{-9}
	Mn 54	S	4×10^{-7}	1×10^{-4}	1×10^{-8}
		I	4×10^{-8}	1×10^{-4}	1×10^{-9}
	Mn 56	S	8×10^{-7}	1×10^{-4}	3×10^{-8}
		I	5×10^{-7}	1×10^{-4}	2×10^{-8}
Mercury (80)	Hg 197m	S	7×10^{-7}	2×10^{-4}	3×10^{-8}
		I	8×10^{-7}	2×10^{-4}	3×10^{-8}
	Hg 197	S	1×10^{-6}	3×10^{-4}	4×10^{-8}
		I	3×10^{-6}	5×10^{-4}	9×10^{-8}
	Hg 203	S	7×10^{-8}	2×10^{-5}	2×10^{-9}
		I	1×10^{-7}	1×10^{-4}	4×10^{-9}
Molybdenum (42)	Mo 99	S	7×10^{-7}	2×10^{-4}	3×10^{-8}
		I	2×10^{-7}	4×10^{-5}	7×10^{-9}
Neodymium (60)	Nd 144	S	8×10^{-11}	7×10^{-5}	3×10^{-12}
		I	3×10^{-10}	8×10^{-5}	1×10^{-11}
	Nd 147	S	4×10^{-7}	6×10^{-5}	1×10^{-8}
		I	2×10^{-7}	6×10^{-5}	8×10^{-9}
	Nd 149	S	2×10^{-6}	3×10^{-4}	6×10^{-8}
		I	1×10^{-6}	3×10^{-4}	5×10^{-8}
Neptunium (93)	Np 237	S	4×10^{-12}	3×10^{-6}	1×10^{-13}
		I	1×10^{-10}	3×10^{-5}	4×10^{-12}
	Np 239	S	8×10^{-7}	1×10^{-4}	3×10^{-8}
		I	7×10^{-7}	1×10^{-4}	2×10^{-8}
Nickel (28)	Ni 59	S	5×10^{-7}	2×10^{-4}	2×10^{-8}
		I	8×10^{-7}	2×10^{-3}	3×10^{-8}
	Ni 63	S	6×10^{-8}	3×10^{-5}	2×10^{-9}
		I	3×10^{-7}	7×10^{-4}	1×10^{-8}
	Ni 65	S	9×10^{-7}	1×10^{-4}	3×10^{-8}
		I	5×10^{-7}	1×10^{-4}	2×10^{-8}

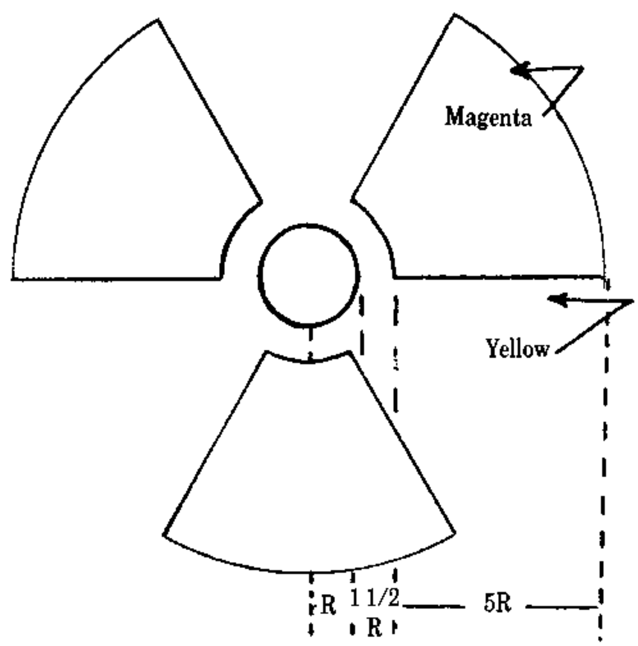
ELEMENT (atomic number)	ISOTOPE[1]		Column 1 AIR (uc/ml)	Column 2 WATER (uc/ml)	Column 3 AIR (uc/ml)
Niobium (Columbium) (41)	Nb 93m	S	1×10^{-7}	4×10^{-4}	4×10^{-9}
		I	2×10^{-7}	4×10^{-4}	5×10^{-9}
	Nb 95	S	5×10^{-7}	1×10^{-4}	2×10^{-8}
		I	1×10^{-7}	1×10^{-4}	3×10^{-9}
	Nb 97	S	6×10^{-6}	9×10^{-4}	2×10^{-7}
		I	5×10^{-6}	9×10^{-4}	2×10^{-7}
Osmium (76)	Os 185	S	5×10^{-7}	7×10^{-5}	2×10^{-8}
		I	5×10^{-8}	7×10^{-5}	2×10^{-9}
	Os 191m	S	2×10^{-5}	3×10^{-3}	6×10^{-7}
		I	9×10^{-6}	2×10^{-3}	3×10^{-7}
	Os 191	S	1×10^{-6}	2×10^{-4}	4×10^{-8}
		I	4×10^{-7}	2×10^{-4}	1×10^{-8}
	Os 193	S	4×10^{-7}	6×10^{-5}	1×10^{-8}
		I	3×10^{-7}	5×10^{-5}	9×10^{-9}
Palladium (46)	Pd 103	S	1×10^{-6}	3×10^{-4}	5×10^{-8}
		I	7×10^{-7}	3×10^{-4}	3×10^{-8}
	Pd 109	S	6×10^{-7}	9×10^{-5}	2×10^{-8}
		I	4×10^{-7}	7×10^{-5}	1×10^{-8}
Phosphorus (15)	P 32	S	7×10^{-8}	2×10^{-5}	2×10^{-9}
		I	8×10^{-8}	2×10^{-5}	3×10^{-9}
Platinum (78)	Pt 191	S	8×10^{-7}	1×10^{-4}	3×10^{-8}
		I	6×10^{-7}	1×10^{-4}	2×10^{-8}
	Pt 193m	S	7×10^{-6}	1×10^{-3}	2×10^{-7}
		I	5×10^{-6}	1×10^{-3}	2×10^{-7}
	Pt 193	S	1×10^{-6}	9×10^{-4}	4×10^{-8}
		I	3×10^{-7}	2×10^{-3}	1×10^{-8}
	Pt 197m	S	6×10^{-6}	1×10^{-3}	2×10^{-7}
		I	5×10^{-6}	9×10^{-4}	2×10^{-7}
	Pt 197	S	8×10^{-7}	1×10^{-4}	3×10^{-8}
		I	6×10^{-7}	1×10^{-4}	2×10^{-8}
Plutonium (94)	Pu 238	S	2×10^{-12}	5×10^{-6}	7×10^{-14}
		I	3×10^{-11}	3×10^{-5}	1×10^{-12}
	Pu 239	S	2×10^{-12}	5×10^{-6}	6×10^{-14}
		I	4×10^{-11}	3×10^{-5}	1×10^{-12}
	Pu 240	S	2×10^{-12}	5×10^{-6}	6×10^{-14}
		I	4×10^{-11}	3×10^{-5}	1×10^{-12}
	Pu 241	S	9×10^{-11}	2×10^{-4}	3×10^{-12}
		I	4×10^{-8}	1×10^{-3}	1×10^{-9}
	Pu 242	S	2×10^{-12}	5×10^{-6}	6×10^{-14}
		I	4×10^{-11}	3×10^{-5}	1×10^{-12}
Polonium (84)	Po 210	S	5×10^{-10}	7×10^{-7}	2×10^{-11}
		I	2×10^{-10}	3×10^{-5}	7×10^{-12}
Potassium (19)	K 42	S	2×10^{-6}	3×10^{-4}	7×10^{-8}
		I	1×10^{-7}	2×10^{-5}	4×10^{-9}
Praseodymium (59)	Pr 142	S	2×10^{-7}	3×10^{-5}	7×10^{-9}
		I	2×10^{-7}	3×10^{-5}	5×10^{-9}
	Pr 143	S	3×10^{-7}	5×10^{-5}	1×10^{-8}
		I	2×10^{-7}	5×10^{-5}	2×10^{-9}
Promethium (61)	Pm 147	S	6×10^{-8}	2×10^{-4}	2×10^{-9}
		I	1×10^{-7}	2×10^{-4}	3×10^{-9}
	Pm 149	S	3×10^{-7}	4×10^{-5}	1×10^{-8}
		I	2×10^{-7}	4×10^{-5}	8×10^{-9}
Protoactinium (91)	Pa 230	S	2×10^{-9}	2×10^{-4}	6×10^{-11}
		I	8×10^{-10}	3×10^{-4}	3×10^{-11}
	Pa 231	S	1×10^{-12}	9×10^{-7}	4×10^{-14}
		I	1×10^{-10}	2×10^{-5}	4×10^{-12}
	Pa 233	S	6×10^{-7}	1×10^{-4}	2×10^{-8}
		I	2×10^{-7}	1×10^{-4}	6×10^{-9}
Radium (88)	Ra 223	S	2×10^{-9}	7×10^{-7}	6×10^{-11}
		I	2×10^{-10}	4×10^{-6}	8×10^{-12}
	Ra 224	S	5×10^{-9}	2×10^{-6}	2×10^{-10}
		I	7×10^{-10}	5×10^{-6}	2×10^{-11}
	Ra 226	S	3×10^{-11}	1×10^{-8}	1×10^{-12}
		I	2×10^{-7}	3×10^{-5}	6×10^{-9}
	Ra 228	S	7×10^{-11}	3×10^{-8}	2×10^{-12}
		I	4×10^{-11}	3×10^{-5}	1×10^{-12}
Radon (86)	Rn 220	S	3×10^{-7}	—	1×10^{-8}
		I	—	—	—
	Rn 222	S	3×10^{-9}	—	1×10^{-9}
Rhenium (75)	Re 183	S	3×10^{-6}	6×10^{-4}	9×10^{-8}
		I	2×10^{-7}	3×10^{-4}	5×10^{-9}
	Re 186	S	6×10^{-7}	9×10^{-5}	2×10^{-8}
		I	2×10^{-7}	5×10^{-5}	8×10^{-9}
	Re 187	S	9×10^{-6}	3×10^{-3}	3×10^{-7}
		I	5×10^{-7}	2×10^{-3}	2×10^{-8}
	Re 188	S	4×10^{-7}	6×10^{-5}	1×10^{-8}
		I	2×10^{-7}	3×10^{-5}	6×10^{-9}
Rhodium (45)	Rh 103m	S	8×10^{-5}	1×10^{-2}	3×10^{-6}
		I	6×10^{-5}	1×10^{-2}	2×10^{-6}
	Rh 105	S	8×10^{-7}	1×10^{-4}	3×10^{-8}
		I	5×10^{-7}	1×10^{-4}	2×10^{-8}
Rubidium (37)	Rb 86	S	3×10^{-7}	7×10^{-5}	1×10^{-8}
		I	7×10^{-8}	2×10^{-5}	2×10^{-9}
	Rb 87	S	5×10^{-7}	1×10^{-4}	2×10^{-8}
		I	7×10^{-8}	2×10^{-4}	2×10^{-9}
Ruthenium (44)	Ru 97	S	2×10^{-6}	4×10^{-4}	8×10^{-8}
		I	2×10^{-6}	3×10^{-4}	6×10^{-8}
	Ru 103	S	5×10^{-7}	8×10^{-5}	2×10^{-8}
		I	8×10^{-8}	8×10^{-5}	3×10^{-9}
	Ru 105	S	7×10^{-7}	1×10^{-4}	2×10^{-8}
		I	5×10^{-7}	1×10^{-4}	2×10^{-8}
	Ru 106	S	8×10^{-8}	1×10^{-5}	3×10^{-9}
		I	6×10^{-9}	1×10^{-5}	2×10^{-10}
Samarium (62)	Sm 147	S	7×10^{-11}	6×10^{-5}	2×10^{-12}
		I	3×10^{-10}	7×10^{-5}	9×10^{-12}
	Sm 151	S	6×10^{-8}	4×10^{-4}	2×10^{-9}
		I	1×10^{-7}	4×10^{-4}	5×10^{-9}
	Sm 153	S	5×10^{-7}	8×10^{-5}	2×10^{-8}
		I	4×10^{-7}	8×10^{-5}	1×10^{-8}
Scandium (21)	Sc 46	S	2×10^{-7}	4×10^{-5}	8×10^{-9}
		I	2×10^{-8}	4×10^{-5}	8×10^{-10}
	Sc 47	S	6×10^{-7}	9×10^{-5}	2×10^{-8}
		I	5×10^{-7}	9×10^{-5}	2×10^{-8}
	Sc 48	S	2×10^{-7}	3×10^{-5}	6×10^{-9}
		I	1×10^{-7}	3×10^{-5}	5×10^{-9}
Selenium (34)	Se 75	S	1×10^{-6}	3×10^{-4}	4×10^{-8}
		I	1×10^{-7}	3×10^{-4}	4×10^{-9}
Silicon (14)	Si 31	S	6×10^{-6}	9×10^{-4}	2×10^{-7}
		I	1×10^{-6}	2×10^{-4}	3×10^{-8}
Silver (47)	Ag 105	S	6×10^{-7}	1×10^{-4}	2×10^{-8}
		I	8×10^{-8}	1×10^{-4}	3×10^{-9}
	Ag 110m	S	2×10^{-7}	3×10^{-5}	7×10^{-9}
		I	1×10^{-8}	3×10^{-5}	3×10^{-10}
	Ag 111	S	3×10^{-7}	4×10^{-5}	1×10^{-8}
		I	2×10^{-7}	4×10^{-5}	8×10^{-9}
Sodium (11)	Na 22	S	2×10^{-7}	4×10^{-5}	6×10^{-9}
		I	9×10^{-9}	3×10^{-5}	3×10^{-10}
	Na 24	S	1×10^{-6}	2×10^{-4}	4×10^{-8}
		I	1×10^{-7}	3×10^{-5}	5×10^{-9}
Strontium (38)	Sr 85m	S	4×10^{-5}	7×10^{-3}	1×10^{-6}
		I	3×10^{-5}	7×10^{-3}	1×10^{-6}
	Sr 85	S	2×10^{-7}	1×10^{-4}	8×10^{-9}
		I	1×10^{-7}	2×10^{-4}	4×10^{-9}
	Sr 89	S	3×10^{-8}	1×10^{-5}	1×10^{-9}
		I	4×10^{-8}	3×10^{-5}	1×10^{-9}
	Sr 90	S	3×10^{-10}	1×10^{-7}	1×10^{-11}
		I	5×10^{-9}	4×10^{-5}	2×10^{-10}
	Sr 91	S	4×10^{-7}	7×10^{-5}	2×10^{-8}
		I	3×10^{-7}	5×10^{-5}	9×10^{-9}
	Sr 92	S	4×10^{-7}	7×10^{-5}	2×10^{-8}
		I	3×10^{-7}	6×10^{-5}	1×10^{-8}
Sulfur (16)	S 35	S	3×10^{-7}	6×10^{-5}	9×10^{-9}
		I	3×10^{-7}	3×10^{-4}	9×10^{-9}
Tantalum (73)	Ta 182	S	4×10^{-8}	4×10^{-5}	1×10^{-9}
		I	2×10^{-8}	4×10^{-5}	7×10^{-10}
Technetium (43)	Tc 96m	S	8×10^{-5}	1×10^{-2}	3×10^{-6}
		I	3×10^{-5}	1×10^{-2}	1×10^{-6}
	Tc 96	S	6×10^{-7}	1×10^{-4}	2×10^{-8}
		I	2×10^{-7}	5×10^{-5}	8×10^{-9}
	Tc 97m	S	2×10^{-6}	4×10^{-4}	8×10^{-8}
		I	2×10^{-7}	2×10^{-4}	5×10^{-9}
	Tc 97	S	1×10^{-5}	2×10^{-3}	4×10^{-7}
		I	3×10^{-7}	8×10^{-4}	1×10^{-8}
	Tc 99m	S	4×10^{-5}	6×10^{-3}	1×10^{-6}
		I	1×10^{-5}	3×10^{-3}	5×10^{-7}
	Tc 99	S	2×10^{-6}	3×10^{-4}	7×10^{-8}
		I	6×10^{-8}	2×10^{-4}	2×10^{-9}
Tellurium (52)	Te 125m	S	4×10^{-7}	2×10^{-4}	1×10^{-8}
		I	1×10^{-7}	1×10^{-4}	4×10^{-9}
	Te 127m	S	1×10^{-7}	6×10^{-5}	5×10^{-9}
		I	4×10^{-8}	5×10^{-5}	1×10^{-9}
	Te 127	S	2×10^{-6}	3×10^{-4}	6×10^{-8}
		I	9×10^{-7}	2×10^{-4}	3×10^{-8}
	Te 129m	S	8×10^{-8}	3×10^{-5}	3×10^{-9}
		I	3×10^{-8}	2×10^{-5}	1×10^{-9}
	Te 129	S	5×10^{-6}	8×10^{-4}	2×10^{-7}
		I	4×10^{-6}	8×10^{-4}	1×10^{-7}
	Te 131m	S	4×10^{-7}	6×10^{-5}	1×10^{-8}
		I	2×10^{-7}	4×10^{-5}	6×10^{-9}
	Te 132	S	2×10^{-7}	3×10^{-5}	7×10^{-9}
		I	1×10^{-7}	2×10^{-5}	4×10^{-9}
Terbium (65)	Tb 160	S	1×10^{-7}	4×10^{-5}	3×10^{-9}
		I	3×10^{-8}	4×10^{-5}	1×10^{-9}
Thallium (81)	Tl 200	S	3×10^{-6}	4×10^{-4}	9×10^{-8}
		I	1×10^{-6}	2×10^{-4}	4×10^{-8}
	Tl 201	S	2×10^{-6}	3×10^{-4}	7×10^{-8}
		I	9×10^{-7}	2×10^{-4}	3×10^{-8}
	Tl 202	S	8×10^{-7}	1×10^{-4}	3×10^{-8}
		I	2×10^{-7}	7×10^{-5}	8×10^{-9}
	Tl 204	S	6×10^{-7}	1×10^{-4}	2×10^{-8}
		I	3×10^{-8}	6×10^{-5}	9×10^{-10}
Thorium (90)	Th 227	S	3×10^{-10}	2×10^{-5}	1×10^{-11}
		I	2×10^{-10}	2×10^{-5}	6×10^{-12}
	Th 228	S	9×10^{-12}	7×10^{-6}	3×10^{-13}
		I	6×10^{-12}	1×10^{-5}	2×10^{-13}
	Th 230	S	2×10^{-12}	2×10^{-6}	8×10^{-14}
		I	1×10^{-11}	3×10^{-5}	3×10^{-13}
	Th 231	S	1×10^{-6}	2×10^{-4}	5×10^{-8}
		I	1×10^{-6}	2×10^{-4}	4×10^{-8}
	Th 232	S	2×10^{-12}	2×10^{-6}	7×10^{-14}
		I	1×10^{-11}	4×10^{-5}	4×10^{-13}
	Th 234	S	6×10^{-8}	2×10^{-5}	2×10^{-9}
		I	3×10^{-8}	2×10^{-5}	1×10^{-9}
	Th natural	S	2×10^{-12}	1×10^{-6}	6×10^{-14}
		I	4×10^{-12}	1×10^{-5}	1×10^{-13}
Thulium (69)	Tm 170	S	4×10^{-8}	5×10^{-5}	1×10^{-9}
		I	3×10^{-8}	5×10^{-5}	1×10^{-9}
	Tm 171	S	1×10^{-7}	5×10^{-4}	4×10^{-9}
		I	2×10^{-7}	5×10^{-4}	8×10^{-9}
Tin (50)	Sn 113	S	4×10^{-7}	9×10^{-5}	1×10^{-8}
		I	5×10^{-8}	8×10^{-5}	2×10^{-9}
	Sn 125	S	1×10^{-7}	2×10^{-5}	4×10^{-9}
		I	8×10^{-8}	2×10^{-5}	3×10^{-9}
Tungsten (Wolfram) (74)	W 181	S	2×10^{-6}	4×10^{-4}	8×10^{-8}
		I	1×10^{-7}	3×10^{-4}	4×10^{-9}
	W 185	S	8×10^{-7}	1×10^{-4}	3×10^{-8}
		I	1×10^{-7}	1×10^{-4}	4×10^{-9}
	W 187	S	4×10^{-7}	7×10^{-5}	2×10^{-8}
		I	3×10^{-7}	6×10^{-5}	1×10^{-8}
Uranium (92)	U 230	S	3×10^{-10}	5×10^{-6}	1×10^{-11}
		I	1×10^{-10}	5×10^{-6}	4×10^{-12}
	U 232	S	1×10^{-10}	3×10^{-5}	3×10^{-12}
		I	3×10^{-11}	3×10^{-5}	9×10^{-13}
	U 233	S	5×10^{-10}	3×10^{-5}	2×10^{-11}
		I	1×10^{-10}	3×10^{-5}	4×10^{-12}
	U 234	S	6×10^{-10}	3×10^{-5}	2×10^{-11}
		I	1×10^{-10}	3×10^{-5}	4×10^{-12}
	U 235	S	5×10^{-10}	3×10^{-5}	2×10^{-11}
		I	1×10^{-10}	3×10^{-5}	4×10^{-12}
	U 236	S	6×10^{-10}	3×10^{-5}	2×10^{-11}
		I	1×10^{-10}	3×10^{-5}	4×10^{-12}
	U 238	S	7×10^{-11}	4×10^{-5}	3×10^{-12}
		I	1×10^{-10}	4×10^{-5}	5×10^{-12}
	U natural	S	7×10^{-11}	2×10^{-5}	3×10^{-12}
		I	6×10^{-11}	2×10^{-5}	2×10^{-12}
Vanadium (23)	V 48	S	2×10^{-7}	3×10^{-5}	6×10^{-9}
		I	6×10^{-8}	3×10^{-5}	2×10^{-9}
Xenon (54)	Xe 131m	Sub	2×10^{-5}	—	4×10^{-7}
	Xe 133	Sub	1×10^{-5}	—	3×10^{-7}
	Xe 135	Sub	4×10^{-6}	—	1×10^{-7}
Ytterbium (70)	Yb 175	S	7×10^{-7}	1×10^{-4}	2×10^{-8}
		I	6×10^{-7}	1×10^{-4}	2×10^{-8}

ELEMENT (atomic number)	ISOTOPE[1]		Column 1 AIR (uc/ml)	Column 2 WATER (uc/ml)	Column 3 AIR (uc/ml)
Yttrium (39)	Y 90	S	1×10^{-7}	2×10^{-5}	4×10^{-9}
		I	1×10^{-7}	$2 \times$ *dd11* 10^{-5}	3×10^{-9}
	Y 91m	S	2×10^{-5}	3×10^{-3}	8×10^{-7}
		I	2×10^{-5}	3×10^{-3}	6×10^{-7}
	Y 91	S	4×10^{-8}	3×10^{-5}	1×10^{-9}
		I	3×10^{-8}	3×10^{-5}	1×10^{-9}
	Y 92	S	4×10^{-7}	6×10^{-5}	1×10^{-8}
		I	3×10^{-7}	6×10^{-5}	1×10^{-8}
	Y 93	S	2×10^{-7}	3×10^{-5}	6×10^{-9}
		I	1×10^{-7}	3×10^{-5}	5×10^{-9}
Zinc (30)	Zn 65	S	1×10^{-7}	1×10^{-4}	4×10^{-9}
		I	6×10^{-8}	2×10^{-4}	2×10^{-9}
	Zn 69m	S	4×10^{-7}	7×10^{-5}	1×10^{-8}
		I	3×10^{-7}	6×10^{-5}	1×10^{-8}
	Zn 69	S	7×10^{-6}	2×10^{-3}	2×10^{-7}
		I	9×10^{-6}	2×10^{-3}	3×10^{-7}
Zirconium (40)	Zr 93	S	1×10^{-7}	8×10^{-4}	4×10^{-9}
		I	3×10^{-7}	8×10^{-4}	1×10^{-8}
	Zr 95	S	1×10^{-7}	6×10^{-5}	4×10^{-9}
		I	3×10^{-8}	6×10^{-5}	1×10^{-9}
	Zr 97	S	1×10^{-7}	2×10^{-5}	4×10^{-9}
		I	9×10^{-8}	2×10^{-5}	3×10^{-9}

EXPLANATORY NOTE: These concentrations may be modified to conform to recommendations promulgated by recognized and authoritative national and international agencies.

APPENDIX II

Radiation Symbol



[1]Soluble (S); Insoluble (I); Submersion in a cloud of gaseous material (Sub.).
[2]Noble gas—Values given for submersion in an infinite cloud.