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3. DOE Guide 424.X, Implementation Guide for Addressing Unreviewed Safety Question (USQ) Requirements, provides DOE's expectations for a USQ process. The contractor must obtain DOE approval of its procedure used to implement the USQ process.

I. FUNCTIONS AND RESPONSIBILITIES

1. The DOE Management Official for a DOE nuclear facility (that is, the Assistant Secretary, the Assistant Administrator, or the Office Director who is primarily responsible for the management of the facility) has primary responsibility within DOE for ensuring that the safety basis for the facility is adequate and complies with the safety basis requirements of Part 830. The DOE Management Official is responsible for ensuring the timely and proper (1) review of all safety basis documents submitted to DOE and (2) preparation of a safety evaluation report concerning the safety basis for a facility.

2. DOE will maintain a public list on the internet that provides the status of the safety basis for each hazard category 1, 2, or 3 DOE nuclear facility and, to the extent practicable, provides information on how to obtain a copy of the safety basis and related documents for a facility.

PART 835—OCCUPATIONAL RADIATION PROTECTION

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APPENDIX E TO PART 835—VALUES FOR ESTABLISHING SEALED RADIOACTIVE SOURCE ACCOUNTABILITY AND RADIOACTIVE MATERIAL POSTING AND LABELING REQUIREMENTS

AUTHORITY: 42 U.S.C. 2201, 7191; 50 U.S.C. 2410.

SOURCE: 58 FR 65485, Dec. 14, 1993, unless otherwise noted.

Subpart A—General Provisions

§ 835.1 Scope.

(a) *General.* The rules in this part establish radiation protection standards, limits, and program requirements for protecting individuals from ionizing radiation resulting from the conduct of DOE activities.

(b) *Exclusion.* Except as provided in paragraph (c) of this section, the requirements in this part do not apply to:

(1) Activities that are regulated through a license by the Nuclear Regulatory Commission or a State under an Agreement with the Nuclear Regulatory commission, including activities certified by the Nuclear Regulatory Commission under section 1701 of the Atomic Energy Act;

(2) Activities conducted under the authority of the Deputy Administrator for Naval Reactors, as described in Pub. L. 98–525 and 106–65;

(3) Activities conducted under the Nuclear Explosives and Weapons Surety Program relating to the prevention of accidental or unauthorized nuclear detonations;

(4) DOE activities conducted outside the United States on territory under the jurisdiction of a foreign government to the extent governed by occupational radiation protection requirements agreed to between the United States and the cognizant government;

(5) Background radiation, radiation doses received as a patient for the purposes of medical diagnosis or therapy, or radiation doses received from participation as a subject in medical research programs; or

(6) Radioactive material on or within material, equipment, and real property which is approved for release when the radiological conditions of the material, equipment, and real property have been documented to comply with the criteria for release set forth in a DOE authorized limit which has been approved by a Secretarial Officer in consultation with the Chief Health, Safety and Security Officer.

(7) Radioactive material transportation not performed by DOE or a DOE contractor.

(c) Occupational doses received as a result of excluded activities and radioactive material transportation listed in paragraphs (b)(1) through (b)(4) and (b)(7) of this section, shall be included to the extent practicable when determining compliance with the occupational dose limits at §§ 835.202 and 835.207, and with the limits for the embryo/fetus at § 835.206. Occupational doses resulting from authorized emergency exposures and planned special exposures shall not be considered when determining compliance with the dose limits at §§ 835.202 and 835.207.

(d) The requirements in subparts F and G of this part do not apply to radioactive material transportation by DOE or a DOE contractor conducted:

(1) Under the continuous observation and control of an individual who is knowledgeable of and implements required exposure control measures, or

(2) In accordance with Department of Transportation regulations or DOE orders that govern such movements.

[58 FR 65485, Dec. 14, 1993, as amended at 63 FR 59679, Nov. 4, 1998; 71 FR 68733, Nov. 28, 2006; 72 FR 31922, June 8, 2007]

§ 835.2 Definitions.

(a) As used in this part:

Accountable sealed radioactive source means a sealed radioactive source having a half-life equal to or greater than 30 days and an isotopic activity equal to or greater than the corresponding value provided in appendix E of this part.

Activity Median Aerodynamic Diameter (AMAD) means a particle size in an aerosol where fifty percent of the activity in the aerosol is associated with particles of aerodynamic diameter greater than the AMAD.

Airborne radioactive material or airborne radioactivity means radioactive material dispersed in the air in the form of dusts, fumes, particulates, mists, vapors, or gases.

Airborne radioactivity area means any area, accessible to individuals, where:

(1) The concentration of airborne radioactivity, above natural background, exceeds or is likely to exceed the derived air concentration (DAC) values listed in appendix A or appendix C of this part; or

(2) An individual present in the area without respiratory protection could receive an intake exceeding 12 DAC-hours in a week.

ALARA means ''As Low As is Reasonably Achievable,'' which is the approach to radiation protection to manage and control exposures (both individual and collective) to the work force and to the general public to as low as is reasonable, taking into account social, technical, economic, practical, and public policy considerations. As used in this part, ALARA is not a dose limit but a process which has the objective of attaining doses as far below the applicable limits of this part as is reasonably achievable.

Annual limit on intake (ALI) means the derived limit for the amount of radioactive material taken into the body of an adult worker by inhalation or ingestion in a year. ALI is the smaller value of intake of a given radionuclide in a year by the reference man (ICRP Publication 23) that would result in a committed effective dose of 5 rems (0.05 sieverts (Sv)) (1 rem = 0.01 Sv) or a committed equivalent dose of 50 rems (0.5 Sv) to any individual organ or tissue. ALI values for intake by ingestion and inhalation of selected radionuclides are based on International Commission on Radiological Protection Publication 68, *Dose Coefficients for Intakes of Radionuclides by Workers*, published July, 1994 (ISBN 0 08 042651 4). This document is available from Elsevier Science Inc., Tarrytown, NY.

Authorized limit means a limit on the concentration of residual radioactive material on the surfaces or within the property that has been derived consistent with DOE directives including the as low as is reasonably achievable (ALARA) process requirements, given the anticipated use of the property and has been authorized by DOE to permit the release of the property from DOE radiological control.

Background means radiation from:

(1) Naturally occurring radioactive materials which have not been technologically enhanced;

(2) Cosmic sources;

(3) Global fallout as it exists in the environment (such as from the testing of nuclear explosive devices);

(4) Radon and its progeny in concentrations or levels existing in buildings or the environment which have not been elevated as a result of current or prior activities; and

(5) Consumer products containing nominal amounts of radioactive material or producing nominal amounts of radiation.

Bioassay means the determination of kinds, quantities, or concentrations, and, in some cases, locations of radioactive material in the human body, whether by direct measurement or by analysis and evaluation of radioactive materials excreted or removed from the human body.

Calibration means to adjust and/or determine either:

(1) The response or reading of an instrument relative to a standard (*e.g.*, primary, secondary, or tertiary) or to a series of conventionally true values; or

(2) The strength of a radiation source relative to a standard (*e.g.*, primary, secondary, or tertiary) or conventionally true value.

Contamination area means any area, accessible to individuals, where removable surface contamination levels exceed or are likely to exceed the removable surface contamination values specified in appendix D of this part, but do not exceed 100 times those values.

Controlled area means any area to which access is managed by or for DOE to protect individuals from exposure to radiation and/or radioactive material.

Declared pregnant worker means a woman who has voluntarily declared to

her employer, in writing, her pregnancy for the purpose of being subject to the occupational dose limits to the embryo/fetus as provided in § 835.206. This declaration may be revoked, in writing, at any time by the declared pregnant worker.

Derived air concentration (DAC) means, for the radionuclides listed in appendix A of this part, the airborne concentration that equals the ALI divided by the volume of air breathed by an average worker for a working year of 2000 hours (assuming a breathing volume of 2400 m^3). For the radionuclides listed in appendix C of this part, the air immersion DACs were calculated for a continuous, non-shielded exposure via immersion in a semi-infinite cloud of radioactive material. Except as noted in the footnotes to appendix A of this part, the values are based on dose coefficients from International Commission on Radiological Protection Publication 68, *Dose Coefficients for Intakes of Radionuclides by Workers*, published July, 1994 (ISBN 0 08 042651 4) and the associated ICRP computer program, *The ICRP Database of Dose Coefficients: Workers and Members of the Public*, (ISBN 0 08 043 8768). These materials are available from Elsevier Science Inc., Tarrytown, NY.

Derived air concentration-hour (DAC-hour) means the product of the concentration of radioactive material in air (expressed as a fraction or multiple of the DAC for each radionuclide) and the time of exposure to that radionuclide, in hours.

Deterministic effects means effects due to radiation exposure for which the severity varies with the dose and for which a threshold normally exists (*e.g.*, radiation-induced opacities within the lens of the eye).

DOE means the United States Department of Energy.

DOE activity means an activity taken for or by DOE in a DOE operation or facility that has the potential to result in the occupational exposure of an individual to radiation or radioactive material. The activity may be, but is not limited to, design, construction, operation, or decommissioning. To the extent appropriate, the activity may involve a single DOE facility or operation or a combination of facilities and operations, possibly including an entire site or multiple DOE sites.

Entrance or access point means any location through which an individual could gain access to areas controlled for the purpose of radiation protection. This includes entry or exit portals of sufficient size to permit human entry, irrespective of their intended use.

General employee means an individual who is either a DOE or DOE contractor employee; an employee of a subcontractor to a DOE contractor; or an individual who performs work for or in conjunction with DOE or utilizes DOE facilities.

High contamination area means any area, accessible to individuals, where removable surface contamination levels exceed or are likely to exceed 100 times the removable surface contamination values specified in appendix D of this part.

High radiation area means any area, accessible to individuals, in which radiation levels could result in an individual receiving an equivalent dose to the whole body in excess of 0.1 rems (0.001 Sv) in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates.

Individual means any human being.

Member of the public means an individual who is not a general employee. An individual is not a ''member of the public'' during any period in which the individual receives an occupational dose.

Minor means an individual less than 18 years of age.

Monitoring means the measurement of radiation levels, airborne radioactivity concentrations, radioactive contamination levels, quantities of radioactive material, or individual doses and the use of the results of these measurements to evaluate radiological hazards or potential and actual doses resulting from exposures to ionizing radiation.

Occupational dose means an individual's ionizing radiation dose (external and internal) as a result of that individual's work assignment. Occupational dose does not include doses received as a medical patient or doses resulting from background radiation or participation as a subject in medical research programs.

Person means any individual, corporation, partnership, firm, association, trust, estate, public or private institution, group, Government agency, any State or political subdivision of, or any political entity within a State, any foreign government or nation or other entity, and any legal successor, representative, agent or agency of the foregoing; provided that person does not include DOE or the United States Nuclear Regulatory Commission.

Radiation means ionizing radiation: alpha particles, beta particles, gamma rays, X-rays, neutrons, high-speed electrons, high-speed protons, and other particles capable of producing ions. Radiation, as used in this part, does not include non-ionizing radiation, such as radio waves or microwaves, or visible, infrared, or ultraviolet light.

Radiation area means any area, accessible to individuals, in which radiation levels could result in an individual receiving an equivalent dose to the whole body in excess of 0.005 rem (0.05 mSv) in 1 hour at 30 centimeters from the source or from any surface that the radiation penetrates.

Radioactive material area means any area within a controlled area, accessible to individuals, in which items or containers of radioactive material exist and the total activity of radioactive material exceeds the applicable values provided in appendix E of this part.

Radioactive material transportation means the movement of radioactive material by aircraft, rail, vessel, or highway vehicle. Radioactive material transportation does not include preparation of material or packagings for transportation, storage of material awaiting transportation, or application of markings and labels required for transportation.

Radiological area means any area within a controlled area defined in this section as a ''radiation area,'' ''high radiation area,'' ''very high radiation area,'' ''contamination area,'' ''high contamination area,'' or ''airborne radioactivity area.''

Radiological worker means a general employee whose job assignment involves operation of radiation producing devices or working with radioactive materials, or who is likely to be routinely occupationally exposed above 0.1 rem (0.001 Sv) per year total effective dose.

Real property means land and anything permanently affixed to the land such as buildings, fences and those things attached to the buildings, such as light fixtures, plumbing and heating fixtures.

Real-time air monitoring means measurement of the concentrations or quantities of airborne radioactive materials on a continuous basis.

Respiratory protective device means an apparatus, such as a respirator, worn by an individual for the purpose of reducing the individual's intake of airborne radioactive materials.

Sealed radioactive source means a radioactive source manufactured, obtained, or retained for the purpose of utilizing the emitted radiation. The sealed radioactive source consists of a known or estimated quantity of radioactive material contained within a sealed capsule, sealed between layer(s) of non-radioactive material, or firmly fixed to a non-radioactive surface by electroplating or other means intended to prevent leakage or escape of the radioactive material. Sealed radioactive sources do not include reactor fuel elements, nuclear explosive devices, and radioisotope thermoelectric generators.

Source leak test means a test to determine if a sealed radioactive source is leaking radioactive material.

Special tritium compound (STC) means any compound, except for H_2O, that contains tritium, either intentionally (*e.g.*, by synthesis) or inadvertently (*e.g.*, by contamination mechanisms).

Stochastic effects means malignant and hereditary diseases for which the probability of an effect occurring, rather than its severity, is regarded as a function of dose without a threshold, for radiation protection purposes.

Very high radiation area means any area, accessible to individuals, in which radiation levels could result in an individual receiving an absorbed dose in excess of 500 rads (5 grays) in one hour at 1 meter from a radiation source or from any surface that the radiation penetrates.

Week means a period of seven consecutive days.

Year means the period of time beginning on or near January 1 and ending on or near December 31 of that same year used to determine compliance with the provisions of this part. The starting and ending date of the year used to determine compliance may be changed, provided that the change is made at the beginning of the year and that no day is omitted or duplicated in consecutive years.

(b) As used in this part to describe various aspects of radiation dose:

Absorbed dose (D) means the average energy imparted by ionizing radiation to the matter in a volume element. The absorbed dose is expressed in units of rad (or gray) (1 rad = 0.01 grays).

Committed effective dose (E_{50}) means the sum of the committed equivalent doses to various tissues or organs in the body ($H_{T,50}$), each multiplied by the appropriate tissue weighting factor (w_T)—that is, $E_{50} = \Sigma w_T H_{T,50} + w_{Remainder} H_{Remainder,50}$. Where $w_{Remainder}$ is the tissue weighting factor assigned to the remainder organs and tissues and $H_{Remainder,50}$ is the committed equivalent dose to the remainder organs and tissues. Committed effective dose is expressed in units of rem (or Sv).

Committed equivalent dose ($H_{T,50}$) means the equivalent dose calculated to be received by a tissue or organ over a 50-year period after the intake of a radionuclide into the body. It does not include contributions from radiation sources external to the body. Committed equivalent dose is expressed in units of rem (or Sv).

Cumulative total effective dose means the sum of all total effective dose values recorded for an individual plus, for occupational exposures received before the implementation date of this amendment, the cumulative total effective dose equivalent (as defined in the November 4, 1998 amendment to this rule) values recorded for an individual, where available, for each year occupational dose was received, beginning January 1, 1989.

Dose is a general term for absorbed dose, equivalent dose, effective dose, committed equivalent dose, committed effective dose, or total effective dose as defined in this part.

Effective dose (E) means the summation of the products of the equivalent dose received by specified tissues or organs of the body (H_T) and the appropriate tissue weighting factor (w_T)—that is, $E = \Sigma w_T H_T$. It includes the dose from radiation sources internal and/or external to the body. For purposes of compliance with this part, equivalent dose to the whole body may be used as effective dose for external exposures. The effective dose is expressed in units of rem (or Sv).

Equivalent dose (H_T) means the product of average absorbed dose ($D_{T,R}$) in rad (or gray) in a tissue or organ (T) and a radiation (R) weighting factor (w_R). For external dose, the equivalent dose to the whole body is assessed at a depth of 1 cm in tissue; the equivalent dose to the lens of the eye is assessed at a depth of 0.3 cm in tissue, and the equivalent dose to the extremity and skin is assessed at a depth of 0.007 cm in tissue. Equivalent dose is expressed in units of rem (or Sv).

External dose or exposure means that portion of the equivalent dose received from radiation sources outside the body (*i.e.*, ''external sources'').

Extremity means hands and arms below the elbow or feet and legs below the knee.

Internal dose or exposure means that portion of the equivalent dose received from radioactive material taken into the body (*i.e.*, ''internal sources'').

Radiation weighting factor (w_R) means the modifying factor used to calculate the equivalent dose from the average tissue or organ absorbed dose; the absorbed dose (expressed in rad or gray) is multiplied by the appropriate radiation weighting factor. The radiation weighting factors to be used for determining equivalent dose in rem are as follows:

RADIATION WEIGHTING FACTORS [1], w_R

Type and energy range	Radiation weighting factor
Photons, electrons and muons, all energies	1
Neutrons, energy < 10 keV [2, 3]	5

RADIATION WEIGHTING FACTORS [1], w_R—Continued

Type and energy range	Radiation weighting factor
Neutrons, energy 10 keV to 100 keV[2, 3]	10
Neutrons, energy > 100 keV to 2 MeV[2, 3]	20
Neutrons, energy > 2 MeV to 20 MeV[2, 3]	10
Neutrons, energy > 20 MeV[2, 3]	5
Protons, other than recoil protons, energy > 2 MeV	5
Alpha particles, fission fragments, heavy nuclei	20

[1] All values relate to the radiation incident on the body or, for internal sources, emitted from the source.
[2] When spectral data are insufficient to identify the energy of the neutrons, a radiation weighting factor of 20 shall be used.
[3] When spectral data are sufficient to identify the energy of the neutrons, the following equation may be used to determine a neutron radiation weighting factor value:

$$w_R = 5 + 17 \exp\left[\frac{-\left(\ln\left(2E_n\right)\right)^2}{6}\right]$$ Where E_n is the neutron energy in MeV.

Tissue weighting factor (w_T) means the fraction of the overall health risk, resulting from uniform, whole body irradiation, attributable to specific tissue (T). The equivalent dose to tissue, (H_T), is multiplied by the appropriate tissue weighting factor to obtain the effective dose (E) contribution from that tissue. The tissue weighting factors are as follows:

TISSUE WEIGHTING FACTORS FOR VARIOUS ORGANS AND TISSUES

Organs or tissues, T	Tissue weighting factor, w_T
Gonads	0.20
Red bone marrow	0.12
Colon	0.12
Lungs	0.12
Stomach	0.12
Bladder	0.05
Breast	0.05
Liver	0.05
Esophagus	0.05
Thyroid	0.05
Skin	0.01
Bone surfaces	0.01
Remainder [1]	0.05
Whole body [2]	1.00

[1] "Remainder" means the following additional tissues and organs and their masses, in grams, following parenthetically: adrenals (14), brain (1400), extrathoracic airways (15), small intestine (640), kidneys (310), muscle (28,000), pancreas (100), spleen (180), thymus (20), and uterus (80). The equivalent dose to the remainder tissues ($H_{remainder}$), is normally calculated as the mass-weighted mean dose to the preceeding ten organs and tissues. In those cases in which the most highly irradiated remainder tissue or organ receives the highest equivalent dose of all the organs, a weighting factor of 0.025 (half of remainder) is applied to that tissue or organ and 0.025 (half of remainder) to the mass-weighted equivalent dose in the rest of the remainder tissues and organs to give the remainder equivalent dose.
[2] For the case of uniform external irradiation of the whole body, a tissue weighting factor (w_T) equal to 1 may be used in determination of the effective dose.

Total effective dose (TED) means the sum of the effective dose (for external exposures) and the committed effective dose.

Whole body means, for the purposes of external exposure, head, trunk (including male gonads), arms above and including the elbow, or legs above and including the knee.

(c) Terms defined in the Atomic Energy Act of 1954 or in 10 CFR part 820 and not defined in this part are used consistent with their meanings given in the Atomic Energy Act of 1954 or in 10 CFR part 820.

[72 FR 31922, June 8, 2007]

§ 835.3 General rule.

(a) No person or DOE personnel shall take or cause to be taken any action inconsistent with the requirements of:

(1) This part; or

(2) Any program, plan, schedule, or other process established by this part.

(b) With respect to a particular DOE activity, contractor management shall be responsible for compliance with the requirements of this part.

(c) Where there is no contractor for a DOE activity, DOE shall ensure implementation of and compliance with the requirements of this part.

(d) Nothing in this part shall be construed as limiting actions that may be necessary to protect health and safety.

(e) For those activities that are required by §§ 835.102, 835.901(e), 835.1202(a), and 835.1202(b), the time interval to

conduct these activities may be extended by a period not to exceed 30 days to accommodate scheduling needs.

[58 FR 65485, Dec. 14, 1993, as amended at 63 FR 59682, Nov. 4, 1998]

§ 835.4 Radiological units.

Unless otherwise specified, the quantities used in the records required by this part shall be clearly indicated in special units of curie, rad, roentgen, or rem, including multiples and subdivisions of these units, or other conventional units, such as, dpm, dpm/100 cm^2 or mass units. The SI units, becquerel (Bq), gray (Gy), and sievert (Sv), may be provided parenthetically for reference with scientific standards.

[72 FR 31925, June 8, 2007]

Subpart B—Management and Administrative Requirements

§ 835.101 Radiation protection programs.

(a) A DOE activity shall be conducted in compliance with a documented radiation protection program (RPP) as approved by the DOE.

(b) The DOE may direct or make modifications to a RPP.

(c) The content of each RPP shall be commensurate with the nature of the activities performed and shall include formal plans and measures for applying the as low as reasonably achievable (ALARA) process to occupational exposure.

(d) The RPP shall specify the existing and/or anticipated operational tasks that are intended to be within the scope of the RPP. Except as provided in § 835.101(h), any task outside the scope of a RPP shall not be initiated until an update of the RPP is approved by DOE.

(e) The content of the RPP shall address, but shall not necessarily be limited to, each requirement in this part.

(f) The RPP shall include plans, schedules, and other measures for achieving compliance with regulations of this part. Unless otherwise specified in this part, compliance with the amendments to this part published on June 8, 2007 shall be achieved no later than July 9, 2010.

(g) An update of the RPP shall be submitted to DOE:

(1) Whenever a change or an addition to the RPP is made;

(2) Prior to the initiation of a task not within the scope of the RPP; or

(3) Within 180 days of the effective date of any modifications to this part.

(h) Changes, additions, or updates to the RPP may become effective without prior Department approval only if the changes do not decrease the effectiveness of the RPP and the RPP, as changed, continues to meet the requirements of this part. Proposed changes that decrease the effectiveness of the RPP shall not be implemented without submittal to and approval by the Department.

(i) An initial RPP or an update shall be considered approved 180 days after its submission unless rejected by DOE at an earlier date.

[58 FR 65485, Dec. 14, 1993, as amended at 63 FR 59682, Nov. 4, 1998; 72 FR 31925, June 8, 2007]

§ 835.102 Internal audits.

Internal audits of the radiation protection program, including examination of program content and implementation, shall be conducted through a process that ensures that all functional elements are reviewed no less frequently than every 36 months.

[63 FR 59682, Nov. 4, 1998]

§ 835.103 Education, training and skills.

Individuals responsible for developing and implementing measures necessary for ensuring compliance with the requirements of this part shall have the appropriate education, training, and skills to discharge these responsibilities.

[63 FR 59682, Nov. 4, 1998]

§ 835.104 Written procedures.

Written procedures shall be developed and implemented as necessary to ensure compliance with this part, commensurate with the radiological hazards created by the activity and consistent with the education, training,

and skills of the individuals exposed to those hazards.

[63 FR 59682, Nov. 4, 1998]

Subpart C—Standards for Internal and External Exposure

§ 835.201 [Reserved]

§ 835.202 Occupational dose limits for general employees.

(a) Except for planned special exposures conducted consistent with § 835.204 and emergency exposures authorized in accordance with § 835.1302, the occupational dose received by general employees shall be controlled such that the following limits are not exceeded in a year:

(1) A total effective dose of 5 rems (0.05 Sv);

(2) The sum of the equivalent dose to the whole body for external exposures and the committed equivalent dose to any organ or tissue other than the skin or the lens of the eye of 50 rems (0.5 Sv);

(3) An equivalent dose to the lens of the eye of 15 rems (0.15 Sv); and

(4) The sum of the equivalent dose to the skin or to any extremity for external exposures and the committed equivalent dose to the skin or to any extremity of 50 rems (0.5 Sv).

(b) All occupational doses received during the current year, except doses resulting from planned special exposures conducted in compliance with § 835.204 and emergency exposures authorized in accordance with § 835.1302, shall be included when demonstrating compliance with §§ 835.202(a) and 835.207.

(c) Doses from background, therapeutic and diagnostic medical radiation, and participation as a subject in medical research programs shall not be included in dose records or in the assessment of compliance with the occupational dose limits.

[58 FR 65485, Dec. 14, 1993, as amended at 63 FR 59682, Nov. 4, 1998; 72 FR 31926, June 8, 2007]

§ 835.203 Combining internal and external equivalent doses.

(a) The total effective dose during a year shall be determined by summing the effective dose from external exposures and the committed effective dose from intakes during the year.

(b) Determinations of the effective dose shall be made using the radiation and tissue weighting factor values provided in § 835.2.

[72 FR 31926, June 8, 2007]

§ 835.204 Planned special exposures.

(a) A planned special exposure may be authorized for a radiological worker to receive doses in addition to and accounted for separately from the doses received under the limits specified in § 835.202(a), provided that each of the following conditions is satisfied:

(1) The planned special exposure is considered only in an exceptional situation when alternatives that might prevent a radiological worker from exceeding the limits in § 835.202(a) are unavailable or impractical;

(2) The contractor management (and employer, if the employer is not the contractor) specifically requests the planned special exposure, in writing; and

(3) Joint written approval is received from the appropriate DOE Headquarters program office and the Secretarial Officer responsible for environment, safety and health matters.

(b) Prior to requesting an individual to participate in an authorized planned special exposure, the individual's dose from all previous planned special exposures and all doses in excess of the occupational dose limits shall be determined.

(c) An individual shall not receive a planned special exposure that, in addition to the doses determined in § 835.204(b), would result in a dose exceeding the following:

(1) In a year, the numerical values of the dose limits established at § 835.202(a); and

(2) Over the individual's lifetime, five times the numerical values of the dose limits established at § 835.202(a).

(d) Prior to a planned special exposure, written consent shall be obtained from each individual involved. Each such written consent shall include:

(1) The purpose of the planned operations and procedures to be used;

(2) The estimated doses and associated potential risks and specific radiological conditions and other hazards which might be involved in performing the task; and

(3) Instructions on the measures to be taken to keep the dose ALARA considering other risks that may be present.

(e) Records of the conduct of a planned special exposure shall be maintained and a written report submitted within 30 days after the planned special exposure to the approving organizations identified in § 835.204(a)(3).

(f) The dose from planned special exposures is not to be considered in controlling future occupational dose of the individual under § 835.202(a), but is to be included in records and reports required under this part.

[58 FR 65485, Dec. 14, 1993, as amended at 63 FR 59682, Nov. 4, 1998]

§ 835.205 Determination of compliance for non-uniform exposure of the skin.

(a) Non-uniform exposures of the skin from X-rays, beta radiation, and/or radioactive material on the skin are to be assessed as specified in this section.

(b) For purposes of demonstrating compliance with § 835.202(a)(4), assessments shall be conducted as follows:

(1) *Area of skin irradiated is 100 cm² or more*. The non-uniform equivalent dose received during the year shall be averaged over the 100 cm² of the skin receiving the maximum dose, added to any uniform equivalent dose also received by the skin, and recorded as the equivalent dose to any extremity or skin for the year.

(2) *Area of skin irradiated is 10 cm² or more, but is less than 100 cm²*. The non-uniform equivalent dose (H) to the irradiated area received during the year shall be added to any uniform equivalent dose also received by the skin and recorded as the equivalent dose to any extremity or skin for the year. H is the equivalent dose averaged over the 1 cm² of skin receiving the maximum absorbed dose, D, reduced by the fraction f, which is the irradiated area in cm² divided by 100 cm² (*i.e.*, H = fD). In no case shall a value of f less than 0.1 be used.

(3) *Area of skin irradiated is less than 10 cm²*. The non-uniform equivalent dose shall be averaged over the 1 cm² of skin receiving the maximum dose. This equivalent dose shall:

(i) Be recorded in the individual's occupational exposure history as a special entry; and

(ii) Not be added to any other equivalent dose to any extremity or skin for the year.

[58 FR 65485, Dec. 14, 1993, as amended at 72 FR 31926, June 8, 2007]

§ 835.206 Limits for the embryo/fetus.

(a) The equivalent dose limit for the embryo/fetus from the period of conception to birth, as a result of occupational exposure of a declared pregnant worker, is 0.5 rem (0.005 Sv).

(b) Substantial variation above a uniform exposure rate that would satisfy the limits provided in § 835.206(a) shall be avoided.

(c) If the equivalent dose to the embryo/fetus is determined to have already exceeded 0.5 rem (0.005 Sv) by the time a worker declares her pregnancy, the declared pregnant worker shall not be assigned to tasks where additional occupational exposure is likely during the remaining gestation period.

[58 FR 65485, Dec. 14, 1993, as amended at 72 FR 31926, June 8, 2007]

§ 835.207 Occupational dose limits for minors.

The dose limits for minors occupationally exposed to radiation and/or radioactive materials at a DOE activity are 0.1 rem (0.001 Sv) total effective dose in a year and 10 percent of the occupational dose limits specified at § 835.202(a)(3) and (a)(4).

[72 FR 31926, June 8, 2007]

§ 835.208 Limits for members of the public entering a controlled area.

The total effective dose limit for members of the public exposed to radiation and/or radioactive material during access to a controlled area is 0.1 rem (0.001 Sv) in a year.

[72 FR 31926, June 8, 2007]

§ 835.209 Concentrations of radioactive material in air.

(a) The derived air concentration (DAC) values given in appendices A and C of this part shall be used in the control of occupational exposures to airborne radioactive material.

(b) The estimation of internal dose shall be based on bioassay data rather than air concentration values unless bioassay data are:

(1) Unavailable;

(2) Inadequate; or

(3) Internal dose estimates based on air concentration values are demonstrated to be as or more accurate.

[58 FR 65485, Dec. 14, 1993, as amended at 63 FR 59682, Nov. 4, 1998]

Subpart D [Reserved]

Subpart E—Monitoring of Individuals and Areas

§ 835.401 General requirements.

(a) Monitoring of individuals and areas shall be performed to:

(1) Demonstrate compliance with the regulations in this part;

(2) Document radiological conditions;

(3) Detect changes in radiological conditions;

(4) Detect the gradual buildup of radioactive material;

(5) Verify the effectiveness of engineered and administrative controls in containing radioactive material and reducing radiation exposure; and

(6) Identify and control potential sources of individual exposure to radiation and/or radioactive material.

(b) Instruments and equipment used for monitoring shall be:

(1) Periodically maintained and calibrated on an established frequency;

(2) Appropriate for the type(s), levels, and energies of the radiation(s) encountered;

(3) Appropriate for existing environmental conditions; and

(4) Routinely tested for operability.

[58 FR 65485, Dec. 14, 1993, as amended at 63 FR 59682, Nov. 4, 1998; 72 FR 31926, June 8, 2007]

§ 835.402 Individual monitoring.

(a) For the purpose of monitoring individual exposures to external radiation, personnel dosimeters shall be provided to and used by:

(1) Radiological workers who, under typical conditions, are likely to receive one or more of the following:

(i) An effective dose of 0.1 rem (0.001 Sv) or more in a year;

(ii) An equivalent dose to the skin or to any extremity of 5 rems (0.05 Sv) or more in a year;

(iii) An equivalent dose to the lens of the eye of 1.5 rems (0.015 Sv) or more in a year;

(2) Declared pregnant workers who are likely to receive from external sources an equivalent dose to the embryo/fetus in excess of 10 percent of the applicable limit at § 835.206(a);

(3) Occupationally exposed minors likely to receive a dose in excess of 50 percent of the applicable limits at § 835.207 in a year from external sources;

(4) Members of the public entering a controlled area likely to receive a dose in excess of 50 percent of the limit at § 835.208 in a year from external sources; and

(5) Individuals entering a high or very high radiation area.

(b) External dose monitoring programs implemented to demonstrate compliance with § 835.402(a) shall be adequate to demonstrate compliance with the dose limits established in subpart C of this part and shall be:

(1) Accredited, or excepted from accreditation, in accordance with the DOE Laboratory Accreditation Program for Personnel Dosimetry; or

(2) Determined by the Secretarial Officer responsible for environment, safety and health matters to have performance substantially equivalent to that of programs accredited under the DOE Laboratory Accreditation Program for Personnel Dosimetry.

(c) For the purpose of monitoring individual exposures to internal radiation, internal dosimetry programs (including routine bioassay programs) shall be conducted for:

(1) Radiological workers who, under typical conditions, are likely to receive a committed effective dose of 0.1 rem (0.001 Sv) or more from all occupational radionuclide intakes in a year;

(2) Declared pregnant workers likely to receive an intake or intakes resulting in an equivalent dose to the embryo/fetus in excess of 10 percent of the limit stated at § 835.206(a);

(3) Occupationally exposed minors who are likely to receive a dose in excess of 50 percent of the applicable limit stated at § 835.207 from all radionuclide intakes in a year; or

(4) Members of the public entering a controlled area likely to receive a dose in excess of 50 percent of the limit stated at § 835.208 from all radionuclide intakes in a year.

(d) Internal dose monitoring programs implemented to demonstrate compliance with § 835.402(c) shall be adequate to demonstrate compliance with the dose limits established in subpart C of this part and shall be:

(1) Accredited, or excepted from accreditation, in accordance with the DOE Laboratory Accreditation Program for Radiobioassay; or,

(2) Determined by the Secretarial Officer responsible for environment, safety and health matters to have performance substantially equivalent to that of programs accredited under the DOE Laboratory Accreditation Program for Radiobioassy.

[63 FR 59683, Nov. 4, 1998, as amended at 72 FR 31926, June 8, 2007]

§ 835.403 Air monitoring.

(a) Monitoring of airborne radioactivity shall be performed:

(1) Where an individual is likely to receive an exposure of 40 or more DAC-hours in a year; or

(2) As necessary to characterize the airborne radioactivity hazard where respiratory protective devices for protection against airborne radionuclides have been prescribed.

(b) Real-time air monitoring shall be performed as necessary to detect and provide warning of airborne radioactivity concentrations that warrant immediate action to terminate inhalation of airborne radioactive material.

[63 FR 59683, Nov. 4, 1998]

§ 835.404 [Reserved]

§ 835.405 Receipt of packages containing radioactive material.

(a) If packages containing quantities of radioactive material in excess of a Type A quantity (as defined at 10 CFR 71.4) are expected to be received from radioactive material transportation, arrangements shall be made to either:

(1) Take possession of the package when the carrier offers it for delivery; or

(2) Receive notification as soon as practicable after arrival of the package at the carrier's terminal and to take possession of the package expeditiously after receiving such notification.

(b) Upon receipt from radioactive material transportation, external surfaces of packages known to contain radioactive material shall be monitored if the package:

(1) Is labeled with a Radioactive White I, Yellow II, or Yellow III label (as specified at 49 CFR 172.403 and 172.436–440); or

(2) Has been transported as low specific activity material (as defined at 10 CFR 71.4) on an exclusive use vehicle (as defined at 10 CFR 71.4); or

(3) Has evidence of degradation, such as packages that are crushed, wet, or damaged.

(c) The monitoring required by paragraph (b) of this section shall include:

(1) Measurements of removable contamination levels, unless the package contains only special form (as defined at 10 CFR 71.4) or gaseous radioactive material; and

(2) Measurements of the radiation levels, if the package contains a Type B quantity (as defined at 10 CFR 71.4) of radioactive material.

(d) The monitoring required by paragraph (b) of this section shall be completed as soon as practicable following receipt of the package, but not later than 8 hours after the beginning of the working day following receipt of the package.

(e) Monitoring pursuant to § 835.405(b) is not required for packages transported on a DOE site which have remained under the continuous observation and control of a DOE employee or DOE contractor employee who is

knowledgeable of and implements required exposure control measures.

[63 FR 59683, Nov. 4, 1998, as amended at 72 FR 31926, June 8, 2007]

Subpart F—Entry Control Program

§ 835.501 Radiological areas.

(a) Personnel entry control shall be maintained for each radiological area.

(b) The degree of control shall be commensurate with existing and potential radiological hazards within the area.

(c) One or more of the following methods shall be used to ensure control:

(1) Signs and barricades;

(2) Control devices on entrances;

(3) Conspicuous visual and/or audible alarms;

(4) Locked entrance ways; or

(5) Administrative controls.

(d) Written authorizations shall be required to control entry into and perform work within radiological areas. These authorizations shall specify radiation protection measures commensurate with the existing and potential hazards.

(e) No control(s) shall be installed at any radiological area exit that would prevent rapid evacuation of personnel under emergency conditions.

[58 FR 65485, Dec. 14, 1993, as amended at 63 FR 59684, Nov. 4, 1998]

§ 835.502 High and very high radiation areas.

(a) The following measures shall be implemented for each entry into a high radiation area:

(1) The area shall be monitored as necessary during access to determine the exposure rates to which the individuals are exposed; and

(2) Each individual shall be monitored by a supplemental dosimetry device or other means capable of providing an immediate estimate of the individual's integrated equivalent dose to the whole body during the entry.

(b) *Physical controls.* One or more of the following features shall be used for each entrance or access point to a high radiation area where radiation levels exist such that an individual could exceed an equivalent dose to the whole body of 1 rem (0.01 sievert) in any one hour at 30 centimeters from the source or from any surface that the radiation penetrates:

(1) A control device that prevents entry to the area when high radiation levels exist or upon entry causes the radiation level to be reduced below that level defining a high radiation area;

(2) A device that functions automatically to prevent use or operation of the radiation source or field while individuals are in the area;

(3) A control device that energizes a conspicuous visible or audible alarm signal so that the individual entering the high radiation area and the supervisor of the activity are made aware of the entry;

(4) Entryways that are locked. During periods when access to the area is required, positive control over each entry is maintained;

(5) Continuous direct or electronic surveillance that is capable of preventing unauthorized entry;

(6) A control device that will automatically generate audible and visual alarm signals to alert personnel in the area before use or operation of the radiation source and in sufficient time to permit evacuation of the area or activation of a secondary control device that will prevent use or operation of the source.

(c) *Very high radiation areas.* In addition to the above requirements, additional measures shall be implemented to ensure individuals are not able to gain unauthorized or inadvertent access to very high radiation areas.

(d) No control(s) shall be established in a high or very high radiation area that would prevent rapid evacuation of personnel.

[58 FR 65485, Dec. 14, 1993, as amended at 63 FR 59684, Nov. 4, 1998; 72 FR 31926, June 8, 2007]

Subpart G—Posting and Labeling

§ 835.601 General requirements.

(a) Except as otherwise provided in this subpart, postings and labels required by this subpart shall include the standard radiation warning trefoil in black or magenta imposed upon a yellow background.

(b) Signs required by this subpart shall be clearly and conspicuously posted and may include radiological protection instructions.

(c) The posting and labeling requirements in this subpart may be modified to reflect the special considerations of DOE activities conducted at private residences or businesses. Such modifications shall provide the same level of protection to individuals as the existing provisions in this subpart.

[63 FR 59684, Nov. 4, 1998]

§ 835.602 Controlled areas.

(a) Each access point to a controlled area (as defined at § 835.2) shall be posted whenever radiological areas or radioactive material areas exist in the area. Individuals who enter only controlled areas without entering radiological areas or radioactive material areas are not expected to receive a total effective dose of more than 0.1 rem (0.001 sievert) in a year.

(b) Signs used for this purpose may be selected by the contractor to avoid conflict with local security requirements.

[58 FR 65485, Dec. 14, 1993, as amended at 63 FR 59684, Nov. 4, 1998; 72 FR 31926, June 8, 2007]

§ 835.603 Radiological areas and radioactive material areas.

Each access point to radiological areas and radioactive material areas (as defined at § 835.2) shall be posted with conspicuous signs bearing the wording provided in this section.

(a) *Radiation area.* The words ''Caution, Radiation Area'' shall be posted at each radiation area.

(b) *High radiation area.* The words ''Caution, High Radiation Area'' or ''Danger, High Radiation Area'' shall be posted at each high radiation area.

(c) *Very high radiation area.* The words ''Grave Danger, Very High Radiation Area'' shall be posted at each very high radiation area.

(d) *Airborne radioactivity area.* The words ''Caution, Airborne Radioactivity Area'' or ''Danger, Airborne Radioactivity Area'' shall be posted at each airborne radioactivity area.

(e) *Contamination area.* The words ''Caution, Contamination Area'' shall be posted at each contamination area.

(f) *High contamination area.* The words ''Caution, High Contamination Area'' or ''Danger, High Contamination Area'' shall be posted at each high contamination area.

(g) *Radioactive material area.* The words ''Caution, Radioactive Material(s)'' shall be posted at each radioactive material area.

[63 FR 59684, Nov. 4, 1998]

§ 835.604 Exceptions to posting requirements.

(a) Areas may be excepted from the posting requirements of § 835.603 for periods of less than 8 continuous hours when placed under continuous observation and control of an individual knowledgeable of, and empowered to implement, required access and exposure control measures.

(b) Areas may be excepted from the radioactive material area posting requirements of § 835.603(g) when:

(1) Posted in accordance with §§ 835.603(a) through (f); or

(2) Each item or container of radioactive material is labeled in accordance with this subpart such that individuals entering the area are made aware of the hazard; or

(3) The radioactive material of concern consists solely of structures or installed components which have been activated (i.e., such as by being exposed to neutron radiation or particles produced by an accelerator).

(c) Areas containing only packages received from radioactive material transportation labeled and in non-degraded condition need not be posted in accordance with § 835.603 until the packages are monitored in accordance with § 835.405.

[63 FR 59684, Nov. 4, 1998]

§ 835.605 Labeling items and containers.

Except as provided at § 835.606, each item or container of radioactive material shall bear a durable, clearly visible label bearing the standard radiation warning trefoil and the words ''Caution, Radioactive Material'' or ''Danger, Radioactive Material.'' The label

shall also provide sufficient information to permit individuals handling, using, or working in the vicinity of the items or containers to take precautions to avoid or control exposures.

[63 FR 59684, Nov. 4, 1998]

§ 835.606 Exceptions to labeling requirements.

(a) Items and containers may be excepted from the radioactive material labeling requirements of § 835.605 when:

(1) Used, handled, or stored in areas posted and controlled in accordance with this subpart and sufficient information is provided to permit individuals to take precautions to avoid or control exposures; or

(2) The quantity of radioactive material is less than one tenth of the values specified in appendix E of this part and less than 0.1 Ci; or

(3) Packaged, labeled, and marked in accordance with the regulations of the Department of Transportation or DOE Orders governing radioactive material transportation; or

(4) Inaccessible, or accessible only to individuals authorized to handle or use them, or to work in the vicinity; or

(5) Installed in manufacturing, process, or other equipment, such as reactor components, piping, and tanks; or

(6) The radioactive material consists solely of nuclear weapons or their components.

(b) Radioactive material labels applied to sealed radioactive sources may be excepted from the color specifications of § 835.601(a).

[63 FR 59684, Nov. 4, 1998, as amended at 72 FR 31927, June 8, 2007]

Subpart H—Records

§ 835.701 General provisions.

(a) Records shall be maintained to document compliance with this part and with radiation protection programs required by § 835.101.

(b) Unless otherwise specified in this subpart, records shall be retained until final disposition is authorized by DOE.

§ 835.702 Individual monitoring records.

(a) Except as authorized by § 835.702(b), records shall be maintained to document doses received by all individuals for whom monitoring was conducted and to document doses received during planned special exposures, unplanned doses exceeding the monitoring thresholds of § 835.402, and authorized emergency exposures.

(b) Recording of the non-uniform equivalent dose to the skin is not required if the dose is less than 2 percent of the limit specified for the skin at § 835.202(a)(4). Recording of internal dose (committed effective dose or committed equivalent dose) is not required for any monitoring result estimated to correspond to an individual receiving less than 0.01 rem (0.1 mSv) committed effective dose. The bioassay or air monitoring result used to make the estimate shall be maintained in accordance with § 835.703(b) and the unrecorded internal dose estimated for any individual in a year shall not exceed the applicable monitoring threshold at § 835.402(c).

(c) The records required by this section shall:

(1) Be sufficient to evaluate compliance with subpart C of this part;

(2) Be sufficient to provide dose information necessary to complete reports required by subpart I of this part;

(3) Include the results of monitoring used to assess the following quantities for external dose received during the year:

(i) The effective dose from external sources of radiation (equivalent dose to the whole body may be used as effective dose for external exposure);

(ii) The equivalent dose to the lens of the eye;

(iii) The equivalent dose to the skin; and

(iv) The equivalent dose to the extremities.

(4) Include the following information for internal dose resulting from intakes received during the year:

(i) Committed effective dose;

(ii) Committed equivalent dose to any organ or tissue of concern; and

(iii) Identity of radionuclides.

(5) Include the following quantities for the summation of the external and internal dose:

(i) Total effective dose in a year;

(ii) For any organ or tissue assigned an internal dose during the year, the

sum of the equivalent dose to the whole body from external exposures and the committed equivalent dose to that organ or tissue; and

(iii) Cumulative total effective dose.

(6) Include the equivalent dose to the embryo/fetus of a declared pregnant worker.

(d) Documentation of all occupational doses received during the current year, except for doses resulting from planned special exposures conducted in compliance with § 835.204 and emergency exposures authorized in accordance with § 835.1302(d), shall be obtained to demonstrate compliance with § 835.202(a). If complete records documenting previous occupational dose during the year cannot be obtained, a written estimate signed by the individual may be accepted to demonstrate compliance.

(e) For radiological workers whose occupational dose is monitored in accordance with § 835.402, reasonable efforts shall be made to obtain complete records of prior years occupational internal and external doses.

(f) The records specified in this section that are identified with a specific individual shall be readily available to that individual.

(g) Data necessary to allow future verification or reassessment of the recorded doses shall be recorded.

(h) All records required by this section shall be transferred to the DOE upon cessation of activities at the site that could cause exposure to individuals.

[58 FR 65485, Dec. 14, 1993, as amended at 63 FR 59685, Nov. 4, 1998; 72 FR 31927, June 8, 2007]

§ 835.703 Other monitoring records.

The following information shall be documented and maintained:

(a) Results of monitoring for radiation and radioactive material as required by subparts E and L of this part, except for monitoring required by § 835.1102(d);

(b) Results of monitoring used to determine individual occupational dose from external and internal sources;

(c) Results of monitoring for the release and control of material and equipment as required by § 835.1101; and

(d) Results of maintenance and calibration performed on instruments and equipment as required by § 835.401(b).

[58 FR 65485, Dec. 14, 1993, as amended at 63 FR 59685, Nov. 4, 1998]

§ 835.704 Administrative records.

(a) Training records shall be maintained, as necessary, to demonstrate compliance with §§ 835.901.

(b) Actions taken to maintain occupational exposures as low as reasonably achievable, including the actions required for this purpose by § 835.101, as well as facility design and control actions required by §§ 835.1001, 835.1002, and 835.1003, shall be documented.

(c) Records shall be maintained to document the results of internal audits and other reviews of program content and implementation.

(d) Written declarations of pregnancy, including the estimated date of conception, and revocations of declarations of pregnancy shall be maintained.

(e) Changes in equipment, techniques, and procedures used for monitoring shall be documented.

(f) Records shall be maintained as necessary to demonstrate compliance with the requirements of §§ 835.1201 and 835.1202 for sealed radioactive source control, inventory, and source leak tests.

[58 FR 65485, Dec. 14, 1993, as amended at 63 FR 59685, Nov. 4, 1998]

Subpart I—Reports to Individuals

§ 835.801 Reports to individuals.

(a) Radiation exposure data for individuals monitored in accordance with § 835.402 shall be reported as specified in this section. The information shall include the data required under § 835.702(c). Each notification and report shall be in writing and include: the DOE site or facility name, the name of the individual, and the individual's social security number, employee number, or other unique identification number.

(b) Upon the request from an individual terminating employment, records of exposure shall be provided to that individual as soon as the data are available, but not later than 90 days after termination. A written estimate

of the radiation dose received by that employee based on available information shall be provided at the time of termination, if requested.

(c) Each DOE- or DOE-contractor-operated site or facility shall, on an annual basis, provide a radiation dose report to each individual monitored during the year at that site or facility in accordance with § 835.402.

(d) Detailed information concerning any individual's exposure shall be made available to the individual upon request of that individual, consistent with the provisions of the Privacy Act (5 U.S.C. 552a).

(e) When a DOE contractor is required to report to the Department, pursuant to Departmental requirements for occurrence reporting and processing, any exposure of an individual to radiation and/or radioactive material, or planned special exposure in accordance with § 835.204(e), the contractor shall also provide that individual with a report on his or her exposure data included therein. Such report shall be transmitted at a time not later than the transmittal to the Department.

[58 FR 65485, Dec. 14, 1993, as amended at 63 FR 59685, Nov. 4, 1998]

Subpart J—Radiation Safety Training

§ 835.901 Radiation safety training.

(a) Each individual shall complete radiation safety training on the topics established at § 835.901(c) commensurate with the hazards in the area and the required controls:

(1) Before being permitted unescorted access to controlled areas; and

(2) Before receiving occupational dose during access to controlled areas at a DOE site or facility.

(b) Each individual shall demonstrate knowledge of the radiation safety training topics established at § 835.901(c), commensurate with the hazards in the area and required controls, by successful completion of an examination and performance demonstrations:

(1) Before being permitted unescorted access to radiological areas; and

(2) Before performing unescorted assignments as a radiological worker.

(c) Radiation safety training shall include the following topics, to the extent appropriate to each individual's prior training, work assignments, and degree of exposure to potential radiological hazards:

(1) Risks of exposure to radiation and radioactive materials, including prenatal radiation exposure;

(2) Basic radiological fundamentals and radiation protection concepts;

(3) Physical design features, administrative controls, limits, policies, procedures, alarms, and other measures implemented at the facility to manage doses and maintain doses ALARA, including both routine and emergency actions;

(4) Individual rights and responsibilities as related to implementation of the facility radiation protection program;

(5) Individual responsibilities for implementing ALARA measures required by § 835.101; and

(6) Individual exposure reports that may be requested in accordance with § 835.801.

(d) When an escort is used in lieu of training in accordance with paragraph (a) or (b) of this section, the escort shall:

(1) Have completed radiation safety training, examinations, and performance demonstrations required for entry to the area and performance of the work; and

(2) Ensure that all escorted individuals comply with the documented radiation protection program.

(e) Radiation safety training shall be provided to individuals when there is a significant change to radiation protection policies and procedures that may affect the individual and at intervals not to exceed 24 months. Such training provided for individuals subject to the requirements of § 835.901(b)(1) and (b)(2) shall include successful completion of an examination.

[63 FR 59685, Nov. 4, 1998]

§§ 835.902–835.903 [Reserved]

Subpart K—Design and Control

§ 835.1001 Design and control.

(a) Measures shall be taken to maintain radiation exposure in controlled areas ALARA through engineered and administrative controls. The primary methods used shall be physical design features (e.g., confinement, ventilation, remote handling, and shielding). Administrative controls shall be employed only as supplemental methods to control radiation exposure.

(b) For specific activities where use of engineered controls is demonstrated to be impractical, administrative controls shall be used to maintain radiation exposures ALARA.

[63 FR 59686, Nov. 4, 1998, as amended at 72 FR 31927, June 8, 2007]

§ 835.1002 Facility design and modifications.

During the design of new facilities or modification of existing facilities, the following objectives shall be adopted:

(a) Optimization methods shall be used to assure that occupational exposure is maintained ALARA in developing and justifying facility design and physical controls.

(b) The design objective for controlling personnel exposure from external sources of radiation in areas of continuous occupational occupancy (2000 hours per year) shall be to maintain exposure levels below an average of 0.5 millirem (5 μSv) per hour and as far below this average as is reasonably achievable. The design objectives for exposure rates for potential exposure to a radiological worker where occupancy differs from the above shall be ALARA and shall not exceed 20 percent of the applicable standards in § 835.202.

(c) Regarding the control of airborne radioactive material, the design objective shall be, under normal conditions, to avoid releases to the workplace atmosphere and in any situation, to control the inhalation of such material by workers to levels that are ALARA; confinement and ventilation shall normally be used.

(d) The design or modification of a facility and the selection of materials shall include features that facilitate operations, maintenance, decontamination, and decommissioning.

[58 FR 65485, Dec. 14, 1993, as amended at 63 FR 59686, Nov. 4, 1998; 72 FR 31927, June 8, 2007]

§ 835.1003 Workplace controls.

During routine operations, the combination of engineered and administrative controls shall provide that:

(a) The anticipated occupational dose to general employees shall not exceed the limits established at § 835.202; and

(b) The ALARA process is utilized for personnel exposures to ionizing radiation.

[63 FR 59686, Nov. 4, 1998, as amended at 72 FR 31927, June 8, 2007]

Subpart L—Radioactive Contamination Control

SOURCE: 63 FR 59686, Nov. 4, 1998, unless otherwise noted.

§ 835.1101 Control of material and equipment.

(a) Except as provided in paragraphs (b) and (c) of this section, material and equipment in contamination areas, high contamination areas, and airborne radioactivity areas shall not be released to a controlled area if:

(1) Removable surface contamination levels on accessible surfaces exceed the removable surface contamination values specified in appendix D of this part; or

(2) Prior use suggests that the removable surface contamination levels on inaccessible surfaces are likely to exceed the removable surface contamination values specified in appendix D of this part.

(b) Material and equipment exceeding the removable surface contamination values specified in appendix D of this part may be conditionally released for movement on-site from one radiological area for immediate placement in another radiological area only if appropriate monitoring is performed and appropriate controls for the movement are established and exercised.

(c) Material and equipment with fixed contamination levels that exceed

the total contamination values specified in appendix D of this part may be released for use in controlled areas outside of radiological areas only under the following conditions:

(1) Removable surface contamination levels are below the removable surface contamination values specified in appendix D of this part; and

(2) The material or equipment is routinely monitored and clearly marked or labeled to alert personnel of the contaminated status.

§ 835.1102 Control of areas.

(a) Appropriate controls shall be maintained and verified which prevent the inadvertent transfer of removable contamination to locations outside of radiological areas under normal operating conditions.

(b) Any area in which contamination levels exceed the values specified in appendix D of this part shall be controlled in a manner commensurate with the physical and chemical characteristics of the contaminant, the radionuclides present, and the fixed and removable surface contamination levels.

(c) Areas accessible to individuals where the measured total surface contamination levels exceed, but the removable surface contamination levels are less than, corresponding surface contamination values specified in appendix D of this part, shall be controlled as follows when located outside of radiological areas:

(1) The area shall be routinely monitored to ensure the removable surface contamination level remains below the removable surface contamination values specified in appendix D of this part; and

(2) The area shall be conspicuously marked to warn individuals of the contaminated status.

(d) Individuals exiting contamination, high contamination, or airborne radioactivity areas shall be monitored, as appropriate, for the presence of surface contamination.

(e) Protective clothing shall be required for entry to areas in which removable contamination exists at levels exceeding the removable surface contamination values specified in appendix D of this part.

Subpart M—Sealed Radioactive Source Control

SOURCE: 63 FR 59686, Nov. 4, 1998, unless otherwise noted.

§ 835.1201 Sealed radioactive source control.

Sealed radioactive sources shall be used, handled, and stored in a manner commensurate with the hazards associated with operations involving the sources.

§ 835.1202 Accountable sealed radioactive sources.

(a) Each accountable sealed radioactive source shall be inventoried at intervals not to exceed six months. This inventory shall:

(1) Establish the physical location of each accountable sealed radioactive source;

(2) Verify the presence and adequacy of associated postings and labels; and

(3) Establish the adequacy of storage locations, containers, and devices.

(b) Except for sealed radioactive sources consisting solely of gaseous radioactive material or tritium, each accountable sealed radioactive source shall be subject to a source leak test upon receipt, when damage is suspected, and at intervals not to exceed six months. Source leak tests shall be capable of detecting radioactive material leakage equal to or exceeding 0.005 μCi.

(c) Notwithstanding the requirements of paragraph (b) of this section, an accountable sealed radioactive source is not subject to periodic source leak testing if that source has been removed from service. Such sources shall be stored in a controlled location, subject to periodic inventory as required by paragraph (a) of this section, and subject to source leak testing prior to being returned to service.

(d) Notwithstanding the requirements of paragraphs (a) and (b) of this section, an accountable sealed radioactive source is not subject to periodic inventory and source leak testing if that source is located in an area that is unsafe for human entry or otherwise inaccessible.

(e) An accountable sealed radioactive source found to be leaking radioactive

material shall be controlled in a manner that minimizes the spread of radioactive contamination.

[63 FR 59686, Nov. 4, 1998, as amended at 72 FR 31927, June 8, 2007]

Subpart N—Emergency Exposure Situations

§ 835.1301 General provisions.

(a) A general employee whose occupational dose has exceeded the numerical value of any of the limits specified in § 835.202 as a result of an authorized emergency exposure may be permitted to return to work in radiological areas during the current year providing that all of the following conditions are met:

(1) Approval is first obtained from the contractor management and the Head of the responsible DOE field organization;

(2) The individual receives counseling from radiological protection and medical personnel regarding the consequences of receiving additional occupational exposure during the year; and

(3) The affected employee agrees to return to radiological work.

(b) All doses exceeding the limits specified in § 835.202 shall be recorded in the affected individual's occupational dose record.

(c) When the conditions under which a dose was received in excess of the limits specified in § 835.202, except those received in accordance with § 835.204, have been eliminated, operating management shall notify the Head of the responsible DOE field organization.

(d) Operations which have been suspended as a result of a dose in excess of the limits specified in § 835.202, except those received in accordance with § 835.204, may be resumed only with the approval of DOE.

[58 FR 65485, Dec. 14, 1993, as amended at 63 FR 59687, Nov. 4, 1998; 72 FR 31927, June 8, 2007]

§ 835.1302 Emergency exposure situations.

(a) The risk of injury to those individuals involved in rescue and recovery operations shall be minimized.

(b) Operating management shall weigh actual and potential risks against the benefits to be gained.

(c) No individual shall be required to perform a rescue action that might involve substantial personal risk.

(d) Each individual authorized to perform emergency actions likely to result in occupational doses exceeding the values of the limits provided at § 835.202(a) shall be trained in accordance with § 835.901(b) and briefed beforehand on the known or anticipated hazards to which the individual will be subjected.

[58 FR 65485, Dec. 14, 1993, as amended at 63 FR 59687, Nov. 4, 1998]

§ 835.1303 [Reserved]

§ 835.1304 Nuclear accident dosimetry.

(a) Installations possessing sufficient quantities of fissile material to potentially constitute a critical mass, such that the excessive exposure of individuals to radiation from a nuclear accident is possible, shall provide nuclear accident dosimetry for those individuals.

(b) Nuclear accident dosimetry shall include the following:

(1) A method to conduct initial screening of individuals involved in a nuclear accident to determine whether significant exposures to radiation occurred;

(2) Methods and equipment for analysis of biological materials;

(3) A system of fixed nuclear accident dosimeter units; and

(4) Personal nuclear accident dosimeters.

[58 FR 65485, Dec. 14, 1993, as amended at 63 FR 59687, Nov. 4, 1998]

Appendix A to Part 835—Derived Air Concentrations (DAC) for Controlling Radiation Exposure to Workers at DOE Facilities

The data presented in appendix A are to be used for controlling individual internal doses in accordance with § 835.209, identifying the need for air monitoring in accordance with § 835.403, and identifying and posting airborne radioactivity areas in accordance with § 835.603(d).

The DAC values are given for individual radionuclides. For known mixtures of radionuclides, determine the sum of the ratio of the observed concentration of a particular

radionuclide and its corresponding DAC for all radionuclides in the mixture. If this sum exceeds unity (1), then the DAC has been exceeded. For unknown radionuclides, the most restrictive DAC (lowest value) for those isotopes not known to be absent shall be used. For any single radionuclide not listed in appendix A with decay mode other than alpha emission or spontaneous fission and with radioactive half-life greater than two hours, the DAC value shall be 4 E-11 μCi/mL (1 Bq/m^3). For any single radionuclide not listed in appendix A that decays by alpha emission or spontaneous fission the DAC value shall be 2 E-13 μCi/mL (8 E-03 Bq/m^3).

The DACs for limiting radiation exposures through inhalation of radionuclides by workers are listed in this appendix. The values are based on either a stochastic (committed effective dose) dose limit of 5 rems (0.05 Sv) or a deterministic (organ or tissue) dose limit of 50 rems (0.5 Sv) per year, whichever is more limiting.

NOTE: the 15 rems (0.15 Sv) dose limit for the lens of the eye does not appear as a critical organ dose limit.

The columns in this appendix contain the following information: (1) Radionuclide; (2) inhaled air DAC for type F (fast), type M (moderate), and type S (slow) materials in units of μCi/mL; (3) inhaled air DAC for type F (fast), type M (moderate), and type S (slow) materials in units of Bq/m^3; (4) an indication of whether or not the DAC for each class is controlled by the stochastic (effective dose) or deterministic (organ or tissue) dose. The absorption types (F, M, and S) have been established to describe the absorption type of the materials from the respiratory tract into the blood. The range of half-times for the absorption types correspond to: Type F, 100% at 10 minutes; Type M, 10% at 10 minutes and 90% at 140 days; and Type S 0.1% at 10 minutes and 99.9% at 7000 days. The DACs are listed by radionuclide, in order of increasing atomic mass, and are based on the assumption that the particle size distribution of 5 micrometers AMAD is used. For situations where the particle size distribution is known to differ significantly from 5 micrometers AMAD, appropriate corrections may be made to both the estimated dose to workers and the DACs.

Radionuclide	Absorption type [3]			Absorption type [3]			Stochastic or organ or tissue [1]
	μCi/mL			Bq/m^3			
	F	M	S	F	M	S	(F/M/S)
H-3 (Water) [2] ..	2 E−05	2 E−05	2 E−05	7 E+05	7 E+05	7 E+05	St/St/St
H-3 (Elemental) [2].	2 E−01	2 E−01	2 E−01	9 E+09	9 E+09	9 E+09	St/St/St
STCs (Insoluble) [4].	1 E−05	6 E−06	2 E−06	3 E+05	2 E+05	8 E+04	St/St/St
STCs (Soluble)	1 E−05	1 E−05	1 E−05	5 E+05	5 E+05	5 E+05	St/St/St
Be-7	–	1 E−05	1 E−05	–	4 E+05	4 E+05	/St/St
Be-10	–	8 E−08	2 E−08	–	3 E+03	1 E+03	/St/St
C-11 (Vapor) [2]	–	1 E−04	–	–	6 E+06	–	/St/
C-11 (CO) [2]	4 E−04	4 E−04	4 E−04	1 E+07	1 E+07	1 E+07	St/St/St
C-11 (CO_2) [2] ...	2 E−04	2 E−04	2 E−04	9 E+06	9 E+06	9 E+06	St/St/St
C-14 (Vapor) [2]	–	9 E−07	–	–	3 E+04	–	/St/
C-14 (CO) [2]	7 E−04	7 E−04	7 E−04	2 E+07	2 E+07	2 E+07	St/St/St
C-14 (CO_2) [2] ...	8 E−05	8 E−05	8 E−05	3 E+06	3 E+06	3 E+06	St/St/St
F-18	4 E−06	3 E−06	3 E−06	1 E+05	1 E+05	1 E+05	ET/ET/ET
Na-22	2 E−07	–	–	1 E+04	–	–	E/ /
Na-24	4 E−07	–	–	1 E+04	–	–	ET/ /
Mg-28	3 E−07	3 E−07	–	1 E+04	1 E+04	–	ET/St/
Al-26	4 E−08	4 E−08	–	1 E+03	1 E+03	–	St/St/
Si-31	9 E−06	5 E−06	5 E−06	3 E+05	1 E+05	1 E+05	ET/St/St
Si-32	1 E−07	5 E−08	1 E−08	5 E+03	2 E+03	3 E+02	St/St/St
P-32	5 E−07	1 E−07	–	1 E+04	7 E+03	–	St/St/
P-33	4 E−06	4 E−07	–	1 E+05	1 E+04	–	St/St/
S-35 (Vapor) ...	–	4 E−06	–	–	1 E+05	–	/St/
S-35	7 E−06	5 E−07	–	2 E+05	1 E+04	–	St/St/
Cl-36	1 E−06	1 E−07	–	4 E+04	4 E+03	–	St/St/
Cl-38	7 E−06	5 E−06	–	2 E+05	2 E+05	–	ET/ET/
Cl-39	2 E−06	4 E−06	–	1 E+05	1 E+05	–	ET/ET/
K-40	1 E−07	–	–	6 E+03	–	–	St/ /
K-42	2 E−06	–	–	1 E+05	–	–	E/ /
K-43	9 E−07	–	–	3 E+04	–	–	ET/ /
K-44	8 E−06	–	–	2 E+05	–	–	ET/ /
K-45	9 E−06	–	–	3 E+05	–	–	ET/ /
Ca-41	–	2 E−06	–	–	8 E+04	–	/BS/
Ca-45	–	2 E−07	–	–	9 E+03	–	/St/
Ca-47	–	2 E−07	–	–	9 E+03	–	/St/
Sc-43	–	–	2 E−06	–	–	7 E+04	/ /ET
Sc-44m	–	–	2 E−07	–	–	1 E+04	/ /St
Sc-44	–	–	1 E−06	–	–	4 E+04	/ /ET

Radionuclide	Absorption type [3]			Absorption type [3]			Stochastic or organ or tissue [1]
	μCi/mL			Bq/m [3]			
	F	M	S	F	M	S	(F/M/S)
Sc-46	–	–	1 E−07	–	–	4 E+03	/ /St
Sc-47	–	–	7 E−07	–	–	2 E+04	/ /St
Sc-48	–	–	2 E−07	–	–	1 E+04	/ /ET
Sc-49	–	–	8 E−06	–	–	3 E+05	/ /ET
Ti-44	7 E−09	2 E−08	9 E−09	2 E+02	7 E+02	3 E+02	St/St/St
Ti-45	3 E−06	2 E−06	2 E−06	1 E+05	1 E+05	1 E+05	ET/ET/ET
V-47	8 E−06	6 E−06	–	3 E+05	2 E+05	–	ET/ET/
V-48	2 E−07	2 E−07	–	9 E+03	7 E+03	–	ET/St/
V-49	1 E−05	2 E−05	–	7 E+05	9 E+05	–	BS/St/
Cr-48	2 E−06	2 E−06	2 E−06	8 E+04	8 E+04	8 E+04	ET/ET/ET
Cr-49	7 E−06	5 E−06	5 E−06	2 E+05	2 E+05	2 E+05	ET/ET/ET
Cr-51	1 E−05	1 E−05	1 E−05	6 E+05	6 E+05	5 E+05	St/St/St
Mn-51	7 E−06	5 E−06	–	2 E+05	2 E+05	–	ET/ET/
Mn-52m	7 E−06	5 E−06	–	2 E+05	2 E+05	–	ET/ET/
Mn-52	2 E−07	2 E−07	–	8 E+03	8 E+03	–	ET/ET/
Mn-53	5 E−06	1 E−05	–	2 E+05	5 E+05	–	BS/St/
Mn-54	5 E−07	4 E−07	–	1 E+04	1 E+04	–	St/St/
Mn-56	2 E−06	2 E−06	–	9 E+04	8 E+04	–	ET/ET/
Fe-52	6 E−07	5 E−07	–	2 E+04	2 E+04	–	ET/E/
Fe-55	6 E−07	1 E−06	–	2 E+04	6 E+04	–	St/St/
Fe-59	1 E−07	1 E−07	–	6 E+03	6 E+03	–	St/St/
Fe-60	1 E−09	4 E−09	–	6 E+01	1 E+02	–	St/St/
Co-55	–	5 E−07	5 E−07	–	2 E+04	2 E+04	/ET/ET
Co-56	–	1 E−07	1 E−07	–	5 E+03	4 E+03	/St/St
Co-57	–	1 E−06	9 E−07	–	5 E+04	3 E+04	/St/St
Co-58m	–	3 E−05	3 E−05	–	1 E+06	1 E+06	/St/St
Co-58	–	4 E−07	3 E−07	–	1 E+04	1 E+04	/St/St
Co-60m	–	4 E−04	4 E−04	–	1 E+07	1 E+07	/St/St
Co-60	–	7 E−08	3 E−08	–	2 E+03	1 E+03	/St/St
Co-61	–	6 E−06	6 E−06	–	2 E+05	2 E+05	/ET/ET
Co-62m	–	7 E−06	6 E−06	–	2 E+05	2 E+05	/ET/ET
Ni-56 (Inorg)	4 E−07	4 E−07	–	1 E+04	1 E+04	–	ET/ET/
Ni-56 (Carbonyl).	–	4 E−07	–	–	1 E+04	–	/St/
Ni-57 (Inorg)	5 E−07	5 E−07	–	2 E+04	2 E+04	–	ET/ET/
Ni-57 (Carbonyl).	–	7 E−07	–	–	2 E+04	–	/ET/
Ni-59 (Inorg)	2 E−06	5 E−06	–	9 E+04	2 E+05	–	St/St/
Ni-59 (Carbonyl).	–	6 E−07	–	–	2 E+04	–	/St/
Ni-63 (Inorg)	1 E−06	1 E−06	–	4 E+04	6 E+04	–	St/St/
Ni-63 (Carbonyl).	–	2 E−07	–	–	1 E+04	–	/St/
Ni-65 (Inorg)	5 E−06	4 E−06	–	1 E+05	1 E+05	–	ET/ET/
Ni-65 (Carbonyl).	–	8 E−07	–	–	3 E+04	–	/ET/
Ni-66 (Inorg)	7 E−07	2 E−07	–	2 E+04	1 E+04	–	St/St/
Ni-66 (Carbonyl).	–	2 E−07	–	–	1 E+04	–	/ET/
Cu-60	5 E−06	4 E−06	4 E−06	1 E+05	1 E+05	1 E+05	ET/ET/ET
Cu-61	3 E−06	3 E−06	3 E−06	1 E+05	1 E+05	1 E+05	ET/ET/ET
Cu-64	4 E−06	3 E−06	3 E−06	1 E+05	1 E+05	1 E+05	ET/E/E
Cu-67	2 E−06	1 E−06	9 E−07	8 E+04	3 E+04	3 E+04	ET/St/St
Zn-62	–	–	8 E−07	–	–	3 E+04	/ /St
Zn-63	–	–	5 E−06	–	–	2 E+05	/ /ET
Zn-65	–	–	2 E−07	–	–	7 E+03	/ /St
Zn-69m	–	–	1 E−06	–	–	6 E+04	/ /St
Zn-69	–	–	7 E−06	–	–	2 E+05	/ /ET
Zn-71m	–	–	1 E−06	–	–	5 E+04	/ /ET
Zn-72	–	–	3 E−07	–	–	1 E+04	/ /St
Ga-65	1 E−05	9 E−06	–	4 E+05	3 E+05	–	ET/ET/
Ga-66	8 E−07	7 E−07	–	3 E+04	2 E+04	–	ET/St/
Ga-67	3 E−06	2 E−06	–	1 E+05	7 E+04	–	ET/St/
Ga-68	6 E−06	4 E−06	–	2 E+05	1 E+05	–	ET/ET/
Ga-70	1 E−05	1 E−05	–	6 E+05	4 E+05	–	ET/ET/
Ga-72	5 E−07	5 E−07	–	2 E+04	2 E+04	–	ET/ET/
Ga-73	4 E−06	2 E−06	–	1 E+05	1 E+05	–	ET/St/
Ge-66	2 E−06	2 E−06	–	9 E+04	9 E+04	–	ET/ET/
Ge-67	1 E−05	7 E−06	–	3 E+05	2 E+05	–	ET/ET/
Ge-68	6 E−07	7 E−08	–	2 E+04	2 E+03	–	ET/St/
Ge-69	1 E−06	1 E−06	–	3 E+04	3 E+04	–	ET/ET/

Radionuclide	Absorption type [3]			Absorption type [3]			Stochastic or organ or tissue [1]
	μCi/mL			Bq/m [3]			
	F	M	S	F	M	S	(F/M/S)
Ge-71	5 E−05	5 E−05	–	2 E+06	1 E+06	–	ET/E/
Ge-75	1 E−05	7 E−06	–	4 E+05	2 E+05	–	ET/ET/
Ge-77	1 E−06	1 E−06	–	4 E+04	4 E+04	–	ET/ET/
Ge-78	3 E−06	3 E−06	–	1 E+05	1 E+05	–	ET/ET/
As-69	–	9 E−06	–	–	3 E+05	–	/ET/
As-70	–	2 E−06	–	–	8 E+04	–	/ET/
As-71	–	1 E−06	–	–	4 E+04	–	/St/
As-72	–	4 E−07	–	–	1 E+04	–	/St/
As-73	–	8 E−07	–	–	3 E+04	–	/St/
As-74	–	3 E−07	–	–	1 E+04	–	/St/
As-76	–	6 E−07	–	–	2 E+04	–	/St/
As-77	–	1 E−06	–	–	4 E+04	–	/St/
As-78	–	3 E−06	–	–	1 E+05	–	/ET/
Se-70	2 E−06	2 E−06	–	1 E+05	9 E+04	–	ET/ET/
Se-73m	1 E−05	1 E−05	–	5 E+05	4 E+05	–	ET/ET/
Se-73	1 E−06	1 E−06	–	6 E+04	5 E+04	–	ET/ET/
Se-75	4 E−07	3 E−07	–	1 E+04	1 E+04	–	St/St/
Se-79	3 E−07	1 E−07	–	1 E+04	6 E+03	–	K/St/
Se-81m	1 E−05	6 E−06	–	3 E+05	2 E+05	–	ET/ET/
Se-81	1 E−05	1 E−05	–	6 E+05	4 E+05	–	ET/ET/
Se-83	6 E−06	5 E−06	–	2 E+05	1 E+05	–	ET/ET/
Br-74m	3 E−06	2 E−06	–	1 E+05	1 E+05	–	ET/ET/
Br-74	4 E−06	4 E−06	–	1 E+05	1 E+05	–	ET/ET/
Br-75	4 E−06	3 E−06	–	1 E+05	1 E+05	–	ET/ET/
Br-76	5 E−07	5 E−07	–	2 E+04	2 E+04	–	ET/ET/
Br-77	2 E−06	2 E−06	–	7 E+04	7 E+04	–	ET/ET/
Br-80m	6 E−06	5 E−06	–	2 E+05	2 E+05	–	ET/St/
Br-80	3 E−05	2 E−05	–	1 E+06	7 E+05	–	ET/ET/
Br-82	3 E−07	3 E−07	–	1 E+04	1 E+04	–	ET/ET/
Br-83	9 E−06	6 E−06	–	3 E+05	2 E+05	–	ET/ET/
Br-84	7 E−06	5 E−06	–	2 E+05	2 E+05	–	ET/ET/
Rb-79	8 E−06	–	–	2 E+05	–	–	ET/ /
Rb-81m	1 E−05	–	–	6 E+05	–	–	ET/ /
Rb-81	2 E−06	–	–	1 E+05	–	–	ET/ /
Rb-82m	8 E−07	–	–	3 E+04	–	–	ET/ /
Rb-83	5 E−07	–	–	2 E+04	–	–	St/ /
Rb-84	3 E−07	–	–	1 E+04	–	–	St/ /
Rb-86	4 E−07	–	–	1 E+04	–	–	St/ /
Rb-87	7 E−07	–	–	2 E+04	–	–	St/ /
Rb-88	1 E−05	–	–	5 E+05	–	–	ET/ /
Rb-89	1 E−05	–	–	3 E+05	–	–	ET/ /
Sr-80	3 E−06	–	2 E−06	1 E+05	–	9 E+04	ET/ /St
Sr-81	7 E−06	–	5 E−06	2 E+05	–	2 E+05	ET/ /ET
Sr-82	1 E−07	–	7 E−08	6 E+03	–	2 E+03	St/ /St
Sr-83	1 E−06	–	9 E−07	3 E+04	–	3 E+04	ET/ /ET
Sr-85m	4 E−05	–	3 E−05	1 E+06	–	1 E+06	ET/ /ET
Sr-85	1 E−06	–	8 E−07	3 E+04	–	3 E+04	St/ /St
Sr-87m	1 E−05	–	9 E−06	4 E+05	–	3 E+05	ET/ /ET
Sr-89	4 E−07	–	1 E−07	1 E+04	–	3 E+03	St/ /St
Sr-90	1 E−08	–	7 E−09	4 E+02	–	2 E+02	BS/ /St
Sr-91	1 E−06	–	9 E−07	5 E+04	–	3 E+04	ET/ /St
Sr-92	2 E−06	–	1 E−06	8 E+04	–	6 E+04	ET/ /St
Y-86m	–	7 E−06	6 E−06	–	2 E+05	2 E+05	/ET/ET
Y-86	–	4 E−07	4 E−07	–	1 E+04	1 E+04	/ET/ET
Y-87	–	9 E−07	8 E−07	–	3 E+04	3 E+04	/ET/ET
Y-88	–	1 E−07	1 E−07	–	6 E+03	6 E+03	/St/St
Y-90m	–	4 E−06	4 E−06	–	1 E+05	1 E+05	/St/St
Y-90	–	3 E−07	3 E−07	–	1 E+04	1 E+04	/St/St
Y-91m	–	2 E−05	2 E−05	–	7 E+05	7 E+05	/ET/ET
Y-91	–	1 E−07	9 E−08	–	4 E+03	3 E+03	/St/St
Y-92	–	2 E−06	2 E−06	–	7 E+04	7 E+04	/St/St
Y-93	–	9 E−07	9 E−07	–	3 E+04	3 E+04	/St/St
Y-94	–	8 E−06	8 E−06	–	3 E+05	3 E+05	/ET/ET
Y-95	–	1 E−05	1 E−05	–	4 E+05	4 E+05	/ET/ET
Zr-86	5 E−07	5 E−07	5 E−07	2 E+04	2 E+04	2 E+04	ET/ET/ET
Zr-88	1 E−07	3 E−07	3 E−07	5 E+03	1 E+04	1 E+04	St/St/St
Zr-89	6 E−07	6 E−07	6 E−07	2 E+04	2 E+04	2 E+04	ET/ET/ET
Zr-93	3 E−09	1 E−08	1 E−07	1 E+02	6 E+02	5 E+03	BS/BS/BS
Zr-95	9 E−08	1 E−07	1 E−07	3 E+03	5 E+03	4 E+03	BS/St/St
Zr-97	7 E−07	4 E−07	4 E−07	2 E+04	1 E+04	1 E+04	ET/St/St
Nb-88	–	5 E−06	5 E−06	–	1 E+05	1 E+05	/ET/ET

Radionuclide	Absorption type [3]			Absorption type [3]			Stochastic or organ or tissue [1]
	μCi/mL			Bq/m [3]			
	F	M	S	F	M	S	(F/M/S)
Nb-89 (66 min)	–	3 E−06	3 E−06	–	1 E+05	1 E+05	/ET/ET
Nb-89 (122 min).	–	2 E−06	2 E−06	–	1 E+05	1 E+05	/ET/ET
Nb-90	–	3 E−07	3 E−07	–	1 E+04	1 E+04	/ET/ET
Nb-93m	–	1 E−06	6 E−07	–	7 E+04	2 E+04	/St/St
Nb-94	–	7 E−08	2 E−08	–	2 E+03	8 E+02	/St/St
Nb-95m	–	7 E−07	6 E−07	–	2 E+04	2 E+04	/St/St
Nb-95	–	4 E−07	4 E−07	–	1 E+04	1 E+04	/St/St
Nb-96	–	4 E−07	4 E−07	–	1 E+04	1 E+04	/ET/ET
Nb-97	–	5 E−06	5 E−06	–	1 E+05	1 E+05	/ET/ET
Nb-98	–	3 E−06	3 E−06	–	1 E+05	1 E+05	/ET/ET
Mo-90	8 E−07	–	7 E−07	3 E+04	–	2 E+04	ET/ /ET
Mo-93m	1 E−06	–	1 E−06	3 E+04	–	3 E+04	ET/ /ET
Mo-93	2 E−07	–	4 E−07	7 E+03	–	1 E+04	BS/ /St
Mo-99	1 E−06	–	5 E−07	5 E+04	–	1 E+04	E/ /St
Mo-101	8 E−06	–	6 E−06	3 E+05	–	2 E+05	ET/ /ET
Tc-93m	8 E−06	7 E−06	–	3 E+05	2 E+05	–	ET/ET/
Tc-93	3 E−06	3 E−06	–	1 E+05	1 E+05	–	ET/ET/
Tc-94m	5 E−06	4 E−06	–	1 E+05	1 E+05	–	ET/ET/
Tc-94	1 E−06	1 E−06	–	4 E+04	3 E+04	–	ET/ET/
Tc-95m	8 E−07	6 E−07	–	3 E+04	2 E+04	–	ET/St/
Tc-95	1 E−06	1 E−06	–	5 E+04	5 E+04	–	ET/ET/
Tc-96m	2 E−05	2 E−05	–	1 E+06	1 E+06	–	ET/ET/
Tc-96	3 E−07	3 E−07	–	1 E+04	1 E+04	–	ET/ET/
Tc-97m	1 E−06	2 E−07	–	5 E+04	7 E+03	–	St/St/
Tc-97	4 E−06	3 E−06	–	1 E+05	1 E+05	–	ET/St/
Tc-98	3 E−07	9 E−08	–	1 E+04	3 E+03	–	St/St/
Tc-99m	1 E−05	1 E−05	–	5 E+05	4 E+05	–	ET/ET/
Tc-99	1 E−06	1 E−07	–	5 E+04	6 E+03	–	St/St/
Tc-101	1 E−05	1 E−05	–	6 E+05	4 E+05	–	ET/ET/
Tc-104	9 E−06	7 E−06	–	3 E+05	2 E+05	–	ET/ET/
Ru-94	5 E−06	5 E−06	5 E−06	2 E+05	1 E+05	1 E+05	ET/ET/ET
Ru-97	2 E−06	2 E−06	2 E−06	8 E+04	8 E+04	8 E+04	ET/ET/ET
Ru-103	8 E−07	2 E−07	2 E−07	3 E+04	1 E+04	9 E+03	St/St/St
Ru-105	2 E−06	2 E−06	2 E−06	9 E+04	8 E+04	8 E+04	ET/ET/ET
Ru-106	5 E−08	3 E−08	1 E−08	2 E+03	1 E+03	5 E+02	St/St/St
Rh-99m	3 E−06	3 E−06	3 E−06	1 E+05	1 E+05	1 E+05	ET/ET/ET
Rh-99	8 E−07	6 E−07	6 E−07	3 E+04	2 E+04	2 E+04	ET/St/St
Rh-100	5 E−07	5 E−07	5 E−07	1 E+04	1 E+04	1 E+04	ET/ET/ET
Rh-101m	1 E−06	1 E−06	1 E−06	6 E+04	6 E+04	6 E+04	ET/ET/ET
Rh-101	3 E−07	3 E−07	1 E−07	1 E+04	1 E+04	6 E+03	St/St/St
Rh-102m	2 E−07	2 E−07	1 E−07	1 E+04	7 E+03	4 E+03	St/St/St
Rh-102	6 E−08	1 E−07	6 E−08	2 E+03	4 E+03	2 E+03	St/St/St
Rh-103m	4 E−04	2 E−04	2 E−04	1 E+07	8 E+06	8 E+06	St/St/St
Rh-105	3 E−06	1 E−06	1 E−06	1 E+05	5 E+04	4 E+04	ET/St/St
Rh-106m	1 E−06	1 E−06	1 E−06	6 E+04	5 E+04	5 E+04	ET/ET/ET
Rh-107	1 E−05	9 E−06	9 E−06	5 E+05	3 E+05	3 E+05	ET/ET/ET
Pd-100	5 E−07	5 E−07	5 E−07	2 E+04	2 E+04	2 E+04	ET/ET/ET
Pd-101	3 E−06	3 E−06	3 E−06	1 E+05	1 E+05	1 E+05	ET/ET/ET
Pd-103	4 E−06	1 E−06	1 E−06	1 E+05	6 E+04	7 E+04	E/St/St
Pd-107	1 E−05	1 E−05	1 E−06	5 E+05	4 E+05	7 E+04	K/St/St
Pd-109	2 E−06	1 E−06	1 E−06	9 E+04	4 E+04	4 E+04	St/St/St
Ag-102	9 E−06	7 E−06	7 E−06	3 E+05	2 E+05	2 E+05	ET/ET/ET
Ag-103	8 E−06	7 E−06	7 E−06	3 E+05	2 E+05	2 E+05	ET/ET/ET
Ag-104m	8 E−06	6 E−06	6 E−06	2 E+05	2 E+05	2 E+05	ET/ET/ET
Ag-104	3 E−06	3 E−06	3 E−06	1 E+05	1 E+05	1 E+05	ET/ET/ET
Ag-105	7 E−07	8 E−07	7 E−07	2 E+04	2 E+04	2 E+04	St/St/St
Ag-106m	2 E−07	2 E−07	2 E−07	9 E+03	9 E+03	9 E+03	ET/ET/ET
Ag-106	1 E−05	1 E−05	1 E−05	5 E+05	4 E+05	4 E+05	ET/ET/ET
Ag-108m	7 E−08	1 E−07	2 E−08	2 E+03	4 E+03	1 E+03	St/St/St
Ag-110m	8 E−08	9 E−08	7 E−08	3 E+03	3 E+03	2 E+03	St/St/St
Ag-111	9 E−07	3 E−07	3 E−07	3 E+04	1 E+04	1 E+04	St/St/St
Ag-112	4 E−06	2 E−06	2 E−06	1 E+05	8 E+04	8 E+04	E/St/St
Ag-115	1 E−05	8 E−06	8 E−06	4 E+05	3 E+05	3 E+05	ET/ET/ET
Cd-104	4 E−06	4 E−06	4 E−06	1 E+05	1 E+05	1 E+05	ET/ET/ET
Cd-107	5 E−06	5 E−06	4 E−06	2 E+05	1 E+05	1 E+05	ET/ET/ET
Cd-109	2 E−08	9 E−08	1 E−07	9 E+02	3 E+03	4 E+03	K/K/St
Cd-113m	1 E−09	6 E−09	1 E−08	6 E+01	2 E+02	6 E+02	K/K/K
Cd-113	1 E−09	5 E−09	1 E−08	5 E+01	2 E+02	5 E+02	K/K/K
Cd-115m	3 E−08	1 E−07	1 E−07	1 E+03	3 E+03	3 E+03	K/St/St
Cd-115	9 E−07	4 E−07	4 E−07	3 E+04	1 E+04	1 E+04	K/St/St

Radionuclide	Absorption type [3]			Absorption type [3]			Stochastic or organ or tissue [1]
	μCi/mL			Bq/m [3]			
	F	M	S	F	M	S	(F/M/S)
Cd-117m	1 E−06	1 E−06	1 E−06	4 E+04	4 E+04	4 E+04	ET/ET/ET
Cd-117	2 E−06	2 E−06	2 E−06	8 E+04	7 E+04	7 E+04	ET/ET/ET
In-109	4 E−06	4 E−06	–	1 E+05	1 E+05	–	ET/ET/
In-110 (69 min)	5 E−06	4 E−06	–	1 E+05	1 E+05	–	ET/ET/
In-110 (5 h)	9 E−07	9 E−07	–	3 E+04	3 E+04	–	ET/ET/
In-111	1 E−06	1 E−06	–	5 E+04	5 E+04	–	ET/ET/
In-112	2 E−05	1 E−05	–	9 E+05	6 E+05	–	ET/ET/
In-113m	1 E−05	1 E−05	–	4 E+05	3 E+05	–	ET/ET/
In-114m	5 E−08	9 E−08	–	1 E+03	3 E+03	–	St/St/
In-115m	6 E−06	5 E−06	–	2 E+05	2 E+05	–	ET/ET/
In-115	1 E−09	5 E−09	–	4 E+01	1 E+02	–	St/St/
In-116m	4 E−06	3 E−06	–	1 E+05	1 E+05	–	ET/ET/
In-117m	5 E−06	4 E−06	–	2 E+05	1 E+05	–	ET/ET/
In-117	7 E−06	5 E−06	–	2 E+05	2 E+05	–	ET/ET/
In-119m	1 E−05	1 E−05	–	6 E+05	4 E+05	–	ET/ET/
Sn-110	1 E−06	1 E−06	–	6 E+04	6 E+04	–	ET/ET/
Sn-111	1 E−05	1 E−05	–	6 E+05	5 E+05	–	ET/ET/
Sn-113	7 E−07	2 E−07	–	2 E+04	1 E+04	–	St/St/
Sn-117m	8 E−07	2 E−07	–	3 E+04	9 E+03	–	BS/St/
Sn-119m	1 E−06	3 E−07	–	5 E+04	1 E+04	–	St/St/
Sn-121m	5 E−07	1 E−07	–	2 E+04	6 E+03	–	St/St/
Sn-121	4 E−06	2 E−06	–	1 E+05	7 E+04	–	ET/St/
Sn-123m	1 E−05	7 E−06	–	4 E+05	2 E+05	–	ET/ET/
Sn-123	3 E−07	1 E−07	–	1 E+04	3 E+03	–	St/St/
Sn-125	4 E−07	2 E−07	–	1 E+04	7 E+03	–	St/St/
Sn-126	4 E−08	3 E−08	–	1 E+03	1 E+03	–	St/St/
Sn-127	2 E−06	2 E−06	–	9 E+04	7 E+04	–	ET/ET/
Sn-128	2 E−06	2 E−06	–	1 E+05	8 E+04	–	ET/ET/
Sb-115	1 E−05	1 E−05	–	5 E+05	4 E+05	–	ET/ET/
Sb-116m	3 E−06	2 E−06	–	1 E+05	1 E+05	–	ET/ET/
Sb-116	1 E−05	1 E−05	–	4 E+05	3 E+05	–	ET/ET/
Sb-117	1 E−05	1 E−05	–	4 E+05	3 E+05	–	ET/ET/
Sb-118m	1 E−06	1 E−06	–	4 E+04	4 E+04	–	ET/ET/
Sb-119	6 E−06	6 E−06	–	2 E+05	2 E+05	–	ET/ET/
Sb-120 (16 min).	2 E−05	2 E−05	–	1 E+06	7 E+05	–	ET/ET/
Sb-120 (6 d)	3 E−07	3 E−07	–	1 E+04	1 E+04	–	ET/ET/
Sb-122	8 E−07	4 E−07	–	3 E+04	1 E+04	–	St/St/
Sb-124m	4 E−05	3 E−05	–	1 E+06	1 E+06	–	ET/ET/
Sb-124	2 E−07	1 E−07	–	1 E+04	4 E+03	–	St/St/
Sb-125	2 E−07	1 E−07	–	7 E+03	6 E+03	–	BS/St/
Sb-126m	1 E−05	7 E−06	–	3 E+05	2 E+05	–	ET/ET/
Sb-126	2 E−07	1 E−07	–	9 E+03	6 E+03	–	ET/St/
Sb-127	7 E−07	3 E−07	–	2 E+04	1 E+04	–	E/St/
Sb-128 (9 h)	5 E−07	5 E−07	–	2 E+04	2 E+04	–	ET/ET/
Sb-128 (10 min).	1 E−05	9 E−06	–	4 E+05	3 E+05	–	ET/ET/
Sb-129	1 E−06	1 E−06	–	6 E+04	5 E+04	–	ET/ET/
Sb-130	3 E−06	2 E−06	–	1 E+05	1 E+05	–	ET/ET/
Sb-131	6 E−06	4 E−06	–	2 E+05	1 E+05	–	ET/ET/
Te-116 (Vapor)	–	6 E−06	–	–	2 E+05	–	/St /
Te-116	2 E−06	2 E−06	–	8 E+04	7 E+04	–	ET/ET/
Te-121m (Vapor).	–	4 E−08	–	–	1 E+03	–	/BS/
Te-121m	1 E−07	1 E−07	–	4 E+03	5 E+03	–	BS/St/
Te-121 (Vapor)	–	1 E−06	–	–	4 E+04	–	/St /
Te-121	1 E−06	1 E−06	–	3 E+04	3 E+04	–	ET/ET/
Te-123m (Vapor).	–	5 E−08	–	–	2 E+03	–	/BS/
Te-123m	1 E−07	1 E−07	–	4 E+03	6 E+03	–	BS/St/
Te-123 (Vapor)	–	1 E−08	–	–	4 E+02	–	/BS/
Te-123	2 E−08	5 E−08	–	1 E+03	1 E+03	–	BS/BS/
Te-125m (Vapor).	–	1 E−07	–	–	3 E+03	–	/BS/
Te-125m	2 E−07	1 E−07	–	9 E+03	7 E+03	–	BS/St/
Te-127m (Vapor).	–	6 E−08	–	–	2 E+03	–	/BS/
Te-127m	1 E−07	9 E−08	–	5 E+03	3 E+03	–	BS/St/
Te-127 (Vapor)	–	7 E−06	–	–	2 E+05	–	/St/
Te-127	5 E−06	3 E−06	–	2 E+05	1 E+05	–	ET/St/
Te-129m (Vapor).	–	1 E−07	–	–	5 E+03	–	/St/

Radionuclide	Absorption type [3]			Absorption type [3]			Stochastic or organ or tissue [1]
	μCi/mL			Bq/m [3]			
	F	M	S	F	M	S	(F/M/S)
Te-129m	3 E−07	1 E−07	–	1 E+04	3 E+03	–	St/St/
Te-129 (Vapor)	–	1 E−05	–	–	5 E+05	–	/St/
Te-129	1 E−05	7 E−06	–	4 E+05	2 E+05	–	ET/ET/
Te-131m (Vapor).	–	1 E−07	–	–	5 E+03	–	/T/
Te-131m	3 E−07	3 E−07	–	1 E+04	1 E+04	–	T/St/
Te-131 (Vapor)	–	6 E−06	–	–	2 E+05	–	/T/
Te-131	1 E−05	7 E−06	–	4 E+05	2 E+05	–	ET/ET/
Te-132 (Vapor)	–	7 E−08	–	–	2 E+03	–	/T/
Te-132	1 E−07	1 E−07	–	6 E+03	6 E+03	–	T/St/
Te-133m (Vapor).	–	1 E−06	–	–	6 E+04	–	/T/
Te-133m	3 E−06	2 E−06	–	1 E+05	1 E+05	–	T/ET/
Te-133 (Vapor)	–	7 E−06	–	–	2 E+05	–	/T/
Te-133	1 E−05	9 E−06	–	4 E+05	3 E+05	–	ET/ET/
Te-134 (Vapor)	–	6 E−06	–	–	2 E+05	–	/St/
Te-134	3 E−06	2 E−06	–	1 E+05	1 E+05	–	ET/ET/
I-120m (Methyl).	4 E−06	–	–	1 E+05	–	–	T/ /
I-120m (Vapor)	–	3 E−06	–	–	1 E+05	–	/St /
I-120m	2 E−06	–	–	8 E+04	–	–	ET/ /
I-120 (Methyl)	1 E−06	–	–	6 E+04	–	–	T/ /
I-120 (Vapor)	–	1 E−06	–	–	5 E+04	–	/T/
I-120	2 E−06	–	–	1 E+05	–	–	E/ /
I-121 (Methyl)	5 E−06	–	–	2 E+05	–	–	T/ /
I-121 (Vapor)	–	4 E−06	–	–	1 E+05	–	/T/
I-121	8 E−06	–	–	3 E+05	–	–	T/ /
I-123 (Methyl)	1 E−06	–	–	7 E+04	–	–	T/ /
I-123 (Vapor)	–	1 E−06	–	–	5 E+04	–	/T/
I-123	2 E−06	–	–	1 E+05	–	–	T/ /
I-124 (Methyl)	3 E−08	–	–	1 E+03	–	–	T/ /
I-124 (Vapor)	–	2 E−08	–	–	9 E+02	–	/T/
I-124	4 E−08	–	–	1 E+03	–	–	T/ /
I-125 (Methyl)	2 E−08	–	–	9 E+02	–	–	T/ /
I-125 (Vapor)	–	2 E−08	–	–	7 E+02	–	/T/
I-125	3 E−08	–	–	1 E+03	–	–	T/ /
I-126 (Methyl)	1 E−08	–	–	5 E+02	–	–	T/ /
I-126 (Vapor)	–	1 E−08	–	–	4 E+02	–	/T/
I-126	2 E−08	–	–	7 E+02	–	–	T/ /
I-128 (Methyl)	3 E−05	–	–	1 E+06	–	–	T/ /
I-128 (Vapor)	–	8 E−06	–	–	3 E+05	–	/St/
I-128	1 E−05	–	–	6 E+05	–	–	ET/ /
I-129 (Methyl)	3 E−09	–	–	1 E+02	–	–	T/ /
I-129 (Vapor)	–	2 E−09	–	–	1 E+02	–	/T/
I-129	5 E−09	–	–	2 E+02	–	–	T/ /
I-130 (Methyl)	2 E−07	–	–	7 E+03	–	–	T/ /
I-130 (Vapor)	–	1 E−07	–	–	6 E+03	–	/T/
I-130	3 E−07	–	–	1 E+04	–	–	T/ /
I-131 (Methyl)	1 E−08	–	–	6 E+02	–	–	T/ /
I-131 (Vapor)	–	1 E−08	–	–	5 E+02	–	/T/
I-131	2 E−08	–	–	9 E+02	–	–	T/ /
I-132m (Methyl).	1 E−06	–	–	7 E+04	–	–	T/ /
I-132m (Vapor)	–	1 E−06	–	–	6 E+04	–	/T/
I-132m	3 E−06	–	–	1 E+05	–	–	T/ /
I-132 (Methyl)	1 E−06	–	–	6 E+04	–	–	T/ /
I-132 (Vapor)	–	1 E−06	–	–	5 E+04	–	/T/
I-132	2 E−06	–	–	7 E+04	–	–	T/ /
I-133 (Methyl)	9 E−08	–	–	3 E+03	–	–	T/ /
I-133 (Vapor)	–	7 E−08	–	–	2 E+03	–	/T/
I-133	1 E−07	–	–	5 E+03	–	–	T/ /
I-134 (Methyl)	8 E−06	–	–	2 E+05	–	–	T/ /
I-134 (Vapor)	–	3 E−06	–	–	1 E+05	–	/St/
I-134	3 E−06	–	–	1 E+05	–	–	ET/ /
I-135 (Methyl)	4 E−07	–	–	1 E+04	–	–	T/ /
I-135 (Vapor)	–	3 E−07	–	–	1 E+04	–	/T/
I-135	6 E−07	–	–	2 E+04	–	–	T/ /
Cs-125	1 E−05	–	–	4 E+05	–	–	ET/ /
Cs-127	4 E−06	–	–	1 E+05	–	–	ET/ /
Cs-129	2 E−06	–	–	9 E+04	–	–	ET/ /
Cs-130	1 E−05	–	–	6 E+05	–	–	ET/ /

Radionuclide	Absorption type [3]			Absorption type [3]			Stochastic or organ or tissue [1]
	μCi/mL			Bq/m [3]			
	F	M	S	F	M	S	(F/M/S)
Cs-131	7 E−06	–	–	2 E+05	–	–	ET/ /
Cs-132	9 E−07	–	–	3 E+04	–	–	ET/ /
Cs-134m	8 E−06	–	–	2 E+05	–	–	ET/ /
Cs-134	5 E−08	–	–	2 E+03	–	–	St/ /
Cs-135m	8 E−06	–	–	2 E+05	–	–	ET/ /
Cs-135	5 E−07	–	–	2 E+04	–	–	St/ /
Cs-136	2 E−07	–	–	1 E+04	–	–	E/ /
Cs-137	8 E−08	–	–	3 E+03	–	–	St/ /
Cs-138	5 E−06	–	–	2 E+05	–	–	ET/ /
Ba-126	4 E−06	–	–	1 E+05	–	–	ET/ /
Ba-128	4 E−07	–	–	1 E+04	–	–	St/ /
Ba-131m	4 E−05	–	–	1 E+06	–	–	ET/ /
Ba-131	1 E−06	–	–	4 E+04	–	–	ET/ /
Ba-133m	2 E−06	–	–	7 E+04	–	–	St/ /
Ba-133	3 E−07	–	–	1 E+04	–	–	St/ /
Ba-135m	2 E−06	–	–	9 E+04	–	–	St/ /
Ba-139	1 E−05	–	–	3 E+05	–	–	St/ /
Ba-140	3 E−07	–	–	1 E+04	–	–	St/ /
Ba-141	1 E−05	–	–	4 E+05	–	–	ET/ /
Ba-142	9 E−06	–	–	3 E+05	–	–	ET/ /
La-131	1 E−05	8 E−06	–	4 E+05	3 E+05	–	ET/ET/
La-132	1 E−06	1 E−06	–	5 E+04	5 E+04	–	ET/ET/
La-135	1 E−05	1 E−05	–	4 E+05	4 E+05	–	ET/ET/
La-137	4 E−08	2 E−07	–	1 E+03	8 E+03	–	L/L/
La-138	3 E−09	1 E−08	–	1 E+02	4 E+02	–	St/St/
La-140	4 E−07	3 E−07	–	1 E+04	1 E+04	–	ET/St/
La-141	5 E−06	2 E−06	–	1 E+05	9 E+04	–	St/St/
La-142	2 E−06	2 E−06	–	9 E+04	8 E+04	–	ET/ET/
La-143	1 E−05	1 E−05	–	6 E+05	4 E+05	–	ET/ET/
Ce-134	–	3 E−07	3 E−07	–	1 E+04	1 E+04	/St/St
Ce-135	–	5 E−07	5 E−07	–	2 E+04	2 E+04	/ET/ET
Ce-137m	–	1 E−06	9 E−07	–	3 E+04	3 E+04	/St/St
Ce-137	–	1 E−05	1 E−05	–	7 E+05	7 E+05	/ET/ET
Ce-139	–	4 E−07	4 E−07	–	1 E+04	1 E+04	/St/St
Ce-141	–	2 E−07	1 E−07	–	7 E+03	6 E+03	/St/St
Ce-143	–	5 E−07	5 E−07	–	2 E+04	2 E+04	/St/St
Ce-144	–	2 E−08	1 E−08	–	9 E+02	7 E+02	/St/St
Pr-136	–	1 E−05	1 E−05	–	3 E+05	3 E+05	/ET/ET
Pr-137	–	9 E−06	9 E−06	–	3 E+05	3 E+05	/ET/ET
Pr-138m	–	2 E−06	2 E−06	–	7 E+04	7 E+04	/ET/ET
Pr-139	–	1 E−05	1 E−05	–	5 E+05	5 E+05	/ET/ET
Pr-142m	–	6 E−05	5 E−05	–	2 E+06	2 E+06	/St/St
Pr-142	–	8 E−07	7 E−07	–	2 E+04	2 E+04	/St/St
Pr-143	–	2 E−07	2 E−07	–	1 E+04	9 E+03	/St/St
Pr-144	–	1 E−05	1 E−05	–	4 E+05	4 E+05	/ET/ET
Pr-145	–	2 E−06	2 E−06	–	8 E+04	8 E+04	/St/St
Pr-147	–	9 E−06	9 E−06	–	3 E+05	3 E+05	/ET/ET
Nd-136	–	4 E−06	4 E−06	–	1 E+05	1 E+05	/ET/ET
Nd-138	–	1 E−06	1 E−06	–	5 E+04	5 E+04	/St/St
Nd-139m	–	1 E−06	1 E−06	–	5 E+04	5 E+04	/ET/ET
Nd-139	–	1 E−05	1 E−05	–	6 E+05	6 E+05	/ET/ET
Nd-141	–	3 E−05	3 E−05	–	1 E+06	1 E+06	/ET/ET
Nd-147	–	2 E−07	2 E−07	–	1 E+04	9 E+03	/St/St
Nd-149	–	4 E−06	4 E−06	–	1 E+05	1 E+05	/ET/ET
Nd-151	–	9 E−06	9 E−06	–	3 E+05	3 E+05	/ET/ET
Pm-141	–	1 E−05	1 E−05	–	4 E+05	4 E+05	/ET/ET
Pm-143	–	5 E−07	6 E−07	–	2 E+04	2 E+04	/St/St
Pm-144	–	1 E−07	1 E−07	–	3 E+03	5 E+03	/St/St
Pm-145	–	1 E−07	4 E−07	–	5 E+03	1 E+04	/BS/St
Pm-146	–	4 E−08	6 E−08	–	1 E+03	2 E+03	/St/St
Pm-147	–	1 E−07	1 E−07	–	4 E+03	6 E+03	/BS/St
Pm-148m	–	1 E−07	1 E−07	–	5 E+03	4 E+03	/St/St
Pm-148	–	2 E−07	2 E−07	–	9 E+03	9 E+03	/St/St
Pm-149	–	7 E−07	6 E−07	–	2 E+04	2 E+04	/St/St
Pm-150	–	2 E−06	2 E−06	–	8 E+04	8 E+04	/ET/ET
Pm-151	–	9 E−07	8 E−07	–	3 E+04	3 E+04	/St/St
Sm-141m	–	5 E−06	–	–	2 E+05	–	/ET/
Sm-141	–	1 E−05	–	–	4 E+05	–	/ET/
Sm-142	–	4 E−06	–	–	1 E+05	–	/ET/
Sm-145	–	4 E−07	–	–	1 E+04	–	/BS/
Sm-146	–	2 E−11	–	–	1 E+00	–	/BS/

Radionuclide	Absorption type [3]			Absorption type [3]			Stochastic or organ or tissue [1]
	μCi/mL			Bq/m [3]			
	F	M	S	F	M	S	(F/M/S)
Sm-147	–	2 E−11	–	–	1 E+00	–	/BS/
Sm-151	–	7 E−08	–	–	2 E+03	–	/BS/
Sm-153	–	8 E−07	–	–	3 E+04	–	/St/
Sm-155	–	1 E−05	–	–	3 E+05	–	/ET/
Sm-156	–	2 E−06	–	–	7 E+04	–	/St/
Eu-145	–	5 E−07	–	–	2 E+04	–	/ET/
Eu-146	–	3 E−07	–	–	1 E+04	–	/ET/
Eu-147	–	5 E−07	–	–	2 E+04	–	/St/
Eu-148	–	2 E−07	–	–	9 E+03	–	/St/
Eu-149	–	2 E−06	–	–	9 E+04	–	/St/
Eu-150 (12 h)	–	2 E−06	–	–	7 E+04	–	/St/
Eu-150 (34 yr)	–	1 E−08	–	–	6 E+02	–	/St/
Eu-152m	–	1 E−06	–	–	6 E+04	–	/St/
Eu-152	–	2 E−08	–	–	7 E+02	–	/St/
Eu-154	–	1 E−08	–	–	5 E+02	–	/St/
Eu-155	–	7 E−08	–	–	2 E+03	–	/BS/
Eu-156	–	1 E−07	–	–	6 E+03	–	/St/
Eu-157	–	1 E−06	–	–	4 E+04	–	/St/
Eu-158	–	5 E−6	–	–	1 E+05	–	/ET/
Gd-145	9 E−06	7 E−06	–	3 E+05	2 E+05	–	ET/ET/
Gd-146	1 E−07	1 E−07	–	4 E+03	4 E+03	–	St/St/
Gd-147	7 E−07	6 E−07	–	2 E+04	2 E+04	–	ET/ET/
Gd-148	5 E−12	2 E−11	–	2 E−01	9 E−01	–	BS/BS/
Gd-149	1 E−06	7 E−07	–	4 E+04	2 E+04	–	St/St/
Gd-151	2 E−07	8 E−07	–	9 E+03	3 E+04	–	BS/St/
Gd-152	7 E−12	3 E−11	–	2 E−01	1 E+00	–	BS/BS/
Gd-153	9 E−08	4 E−07	–	3 E+03	1 E+04	–	BS/St/
Gd-159	3 E−06	1 E−06	–	1 E+05	5 E+04	–	St/St/
Tb-147	–	2 E−06	–	–	1 E+05	–	/ET/
Tb-149	–	1 E−07	–	–	6 E+03	–	/St/
Tb-150	–	2 E−06	–	–	8 E+04	–	/ET/
Tb-151	–	1 E−06	–	–	4 E+04	–	/ET/
Tb-153	–	2 E−06	–	–	8 E+04	–	/St/
Tb-154	–	5 E−07	–	–	2 E+04	–	/ET/
Tb-155	–	2 E−06	–	–	8 E+04	–	/St/
Tb-156m (24 h)	–	2 E−06	–	–	9 E+04	–	/St/
Tb-156m (5 h)	–	4 E−06	–	–	1 E+05	–	/St/
Tb-156	–	4 E−07	–	–	1 E+04	–	/E/
Tb-157	–	2 E−07	–	–	8 E+03	–	/BS/
Tb-158	–	1 E−08	–	–	6 E+02	–	/BS/
Tb-160	–	1 E−07	–	–	3 E+03	–	/St/
Tb-161	–	4 E−07	–	–	1 E+04	–	/St/
Dy-155	–	2 E−06	–	–	1 E+05	–	/ET/
Dy-157	–	5 E−06	–	–	1 E+05	–	/ET/
Dy-159	–	2 E−06	–	–	8 E+04	–	/BS/
Dy-165	–	6 E−06	–	–	2 E+05	–	/ET/
Dy-166	–	3 E−07	–	–	1 E+04	–	/St/
Ho-155	–	1 E−05	–	–	4 E+05	–	/ET/
Ho-157	–	2 E−05	–	–	1 E+06	–	/ET/
Ho-159	–	2 E−05	–	–	9 E+05	–	/ET/
Ho-161	–	3 E−05	–	–	1 E+06	–	/ET/
Ho-162m	–	9 E−06	–	–	3 E+05	–	/ET/
Ho-162	–	5 E−05	–	–	2 E+06	–	/ET/
Ho-164m	–	3 E−05	–	–	1 E+06	–	/St/
Ho-164	–	2 E−05	–	–	8 E+05	–	/ET/
Ho-166m	–	7 E−09	–	–	2 E+02	–	/St/
Ho-166	–	6 E−07	–	–	2 E+04	–	/St/
Ho-167	–	4 E−06	–	–	1 E+05	–	/ET/
Er-161	–	3 E−06	–	–	1 E+05	–	/ET/
Er-165	–	2 E−05	–	–	1 E+06	–	/ET/
Er-169	–	6 E−07	–	–	2 E+04	–	/St/
Er-171	–	1 E−06	–	–	6 E+04	–	/St/
Er-172	–	4 E−07	–	–	1 E+04	–	/St/
Tm-162	–	9 E−06	–	–	3E+05	–	/ET/
Tm-166	–	1 E−06	–	–	4 E+04	–	/ET/
Tm-167	–	5 E−07	–	–	2 E+04	–	/St/
Tm-170	–	1 E−07	–	–	4 E+03	–	/St/
Tm-171	–	2 E−07	–	–	9 E+03	–	/BS/
Tm-172	–	4 E−07	–	–	1 E+04	–	/St/
Tm-173	–	2 E−06	–	–	8 E+04	–	/St/
Tm-175	–	8 E−06	–	–	2 E+05	–	/ET/

Radionuclide	Absorption type [3]			Absorption type [3]			Stochastic or organ or tissue [1]
	μCi/mL			Bq/m [3]			
	F	M	S	F	M	S	(F/M/S)
Yb-162	–	1 E−05	1 E−05	–	5 E+05	5 E+05	/ET/ET
Yb-166	–	6 E−07	5 E−07	–	2 E+04	2 E+04	/St/St
Yb-167	–	3 E−05	3 E−05	–	1 E+06	1 E+06	/ET/ET
Yb-169	–	2 E−07	2 E−07	–	9 E+03	8 E+03	/St/St
Yb-175	–	8 E−07	8 E−07	–	3 E+04	2 E+04	/St/St
Yb-177	–	6 E−06	5 E−06	–	2 E+05	2 E+05	/ET/ET
Yb-178	–	5 E−06	5 E−06	–	1 E+05	1 E+05	/ET/E
Lu-169	–	9 E−07	9 E−07	–	3 E+04	3 E+04	/ET/ET
Lu-170	–	4 E−07	4 E−07	–	1 E+04	1 E+04	/ET/ET
Lu-171	–	6 E−07	6 E−07	–	2 E+04	2 E+04	/St/St
Lu-172	–	3 E−07	3 E−07	–	1 E+04	1 E+04	/St/St
Lu-173	–	2 E−07	4 E−07	–	8 E+03	1 E+04	/BS/St
Lu-174m	–	2 E−07	2 E−07	–	7 E+03	8 E+03	/BS/St
Lu-174	–	9 E−08	2 E−07	–	3 E+03	8 E+03	/BS/St
Lu-176m	–	3 E−06	3 E−06	–	1 E+05	1 E+05	/St/St
Lu-176	–	3 E−09	1 E−08	–	1 E+02	6 E+02	/BS/St
Lu-177m	–	5 E−08	4 E−08	–	2 E+03	1 E+03	/St/St
Lu-177	–	5 E−07	5 E−07	–	2 E+04	1 E+04	/St/St
Lu-178m	–	4 E−06	4 E−06	–	1 E+05	1 E+05	/ET/ET
Lu-178	–	8 E−06	8 E−06	–	3 E+05	3 E+05	/ET/ET
Lu-179	–	3 E−06	3 E−06	–	1 E+05	1 E+05	/St/St
Hf-170	1 E−06	1 E−06	–	4 E+04	4 E+04	–	ET/ET/
Hf-172	6 E−09	3 E−08	–	2 E+02	1 E+03	–	BS/BS/
Hf-173	2 E−06	2 E−06	–	9 E+04	8 E+04	–	ET/ET/
Hf-175	5 E−07	6 E−07	–	2 E+04	2 E+04	–	BS/St/
Hf-177m	2 E−06	1 E−06	–	9 E+04	6 E+04	–	ET/ET/
Hf-178m	8 E−10	4 E−09	–	3 E+01	1 E+02	–	BS/BS/
Hf-179m	2 E−07	1 E−07	–	8 E+03	6 E+03	–	BS/St/
Hf-180m	2 E−06	1 E−06	–	7 E+04	6 E+04	–	ET/ET/
Hf-181	1 E−07	1 E−07	–	4 E+03	5 E+03	–	BS/St/
Hf-182m	5 E−06	4 E−06	–	2 E+05	1 E+05	–	ET/ET/
Hf-182	5 E−10	2 E−09	–	2 E+01	9 E+01	–	BS/BS/
Hf-183	6 E−06	4 E−06	–	2 E+05	1 E+05	–	ET/ET/
Hf-184	1 E−06	1 E−06	–	5 E+04	4 E+04	–	ET/St/
Ta-172	–	5 E−06	5 E−06	–	1 E+05	1 E+05	/ET/ET
Ta-173	–	3 E−06	3 E−06	–	1 E+05	1 E+05	/E/E
Ta-174	–	5 E−06	5 E−06	–	2 E+05	2 E+05	/ET/ET
Ta-175	–	1 E−06	1 E−06	–	6 E+04	6 E+04	/ET/ET
Ta-176	–	1 E−06	1 E−06	–	3 E+04	3 E+04	/ET/ET
Ta-177	–	4 E−06	4 E−06	–	1 E+05	1 E+05	/St/St
Ta-178	–	3 E−06	3 E−06	–	1 E+05	1 E+05	/ET/ET
Ta-179	–	4 E−06	1 E−06	–	1 E+05	7 E+04	/St/St
Ta-180m	–	9 E−06	9 E−06	–	3 E+05	3 E+05	/St/St
Ta-180	–	1 E−07	4 E−08	–	4 E+03	1 E+03	/St/St
Ta-182m	–	6 E−06	6 E−06	–	2 E+05	2 E+05	/ET/ET
Ta-182	–	9 E−08	7 E−08	–	3 E+03	2 E+03	/St/St
Ta-183	–	3 E−07	2 E−07	–	1 E+04	1 E+04	/St/St
Ta-184	–	8 E−07	8 E−07	–	3 E+04	3 E+04	/ET/ET
Ta-185	–	5 E−06	5 E−06	–	2 E+05	1 E+05	/ET/ET
Ta-186	–	7 E−06	7 E−06	–	2 E+05	2 E+05	/ET/ET
W-176	3 E−06	–	–	1 E+05	–	–	ET/ /
W-177	5 E−06	–	–	2 E+05	–	–	ET/ /
W-178	3 E−06	–	–	1 E+05	–	–	ET/ /
W-179	1 E−04	–	–	5 E+06	–	–	ET/ /
W-181	1 E−05	–	–	4 E+05	–	–	ET/ /
W-185	2 E−06	–	–	9 E+04	–	–	St/ /
W-187	1 E−06	–	–	5 E+04	–	–	ET/ /
W-188	6 E−07	–	–	2 E+04	–	–	St/ /
Re-177	1 E−05	1 E−05	–	6 E+05	4 E+05	–	ET/ET/
Re-178	1 E−05	1 E−05	–	5 E+05	3 E+05	–	ET/ET/
Re-181	1 E−06	1 E−06	–	5 E+04	4 E+04	–	ET/ET/
Re-182 (64 h)	4 E−07	3 E−07	–	1 E+04	1 E+04	–	ET/St/
Re-182 (12 h)	1 E−06	1 E−06	–	4 E+04	4 E+04	–	ET/ET/
Re-184m	6 E−07	1 E−07	–	2 E+04	4 E+03	–	St/St/
Re-184	7 E−07	3 E−07	–	2 E+04	1 E+04	–	ET/St/
Re-186m	4 E−7	7 E−08	–	1 E+04	2 E+03	–	St/St/
Re-186	7 E−07	4 E−07	–	2 E+04	1 E+04	–	St/St/
Re-187	2 E−04	1 E−04	–	8 E+06	4 E+06	–	St/St/
Re-188m	3 E−05	2 E−05	–	1 E+06	1 E+06	–	St/St/
Re-188	8 E−07	7 E−07	–	3 E+04	2 E+04	–	St/St/
Re-189	1 E−06	9 E−07	–	4 E+04	3 E+04	–	St/St/

Radionuclide	Absorption type [3]			Absorption type [3]			Stochastic or organ or tissue [1]
	μCi/mL			Bq/m [3]			
	F	M	S	F	M	S	(F/M/S)
Os-180	1 E−05	1 E−05	1 E−05	5 E+05	3 E+05	3 E+05	ET/ET/ET
Os-181	3 E−06	3 E−06	3 E−06	1 E+05	1 E+05	1 E+05	ET/ET/ET
Os-182	1 E−06	9 E−07	9 E−07	3 E+04	3 E+04	3 E+04	ET/ET/ET
Os-185	4 E−07	5 E−07	5 E−07	1 E+04	2 E+04	1 E+04	St/St/St
Os-189m	1 E−04	7 E−05	7 E−05	4 E+06	2 E+06	2 E+06	St/St/St
Os-191m	1 E−05	4 E−06	4 E−06	5 E+05	1 E+05	1 E+05	St/St/St
Os-191	1 E−06	4 E−07	3 E−07	5 E+04	1 E+04	1 E+04	St/St/St
Os-193	2 E−06	8 E−07	8 E−07	7 E+04	3 E+04	3 E+04	St/St/St
Os-194	4 E−08	4 E−08	1 E−08	1 E+03	1 E+03	4 E+02	St/St/St
Ir-182	9 E−06	7 E−06	7 E−06	3 E+05	2 E+05	2 E+05	ET/ET/ET
Ir-184	1 E−06	1 E−06	1 E−06	7 E+04	6 E+04	7 E+04	ET/ET/ET
Ir-185	2 E−06	1 E−06	1 E−06	7 E+04	7 E+04	7 E+04	ET/ET/ET
Ir-186 (16 h)	8 E−07	7 E−07	7 E−07	2 E+04	2 E+04	2 E+04	ET/ET/ET
Ir-186 (2 h)	5 E−06	4 E−06	4 E−06	1 E+05	1 E+05	1 E+05	ET/ET/ET
Ir-187	4 E−06	3 E−06	3 E−06	1 E+05	1 E+05	1 E+05	ET/ET/ET
Ir-188	6 E−07	6 E−07	6 E−07	2 E+04	2 E+04	2 E+04	ET/ET/ET
Ir-189	3 E−06	1 E−06	1 E−06	1 E+05	5 E+04	4 E+04	St/St/St
Ir-190m (3 h)	2 E−06	2 E−06	2 E−06	8 E+04	8 E+04	7 E+04	ET/ET/ET
Ir-190m (1 h)	9 E−05	5 E−05	5 E−05	3 E+06	2 E+06	1 E+06	ET/St/St
Ir-190	4 E−07	2 E−07	2 E−07	1 E+04	9 E+03	8 E+03	ET/St/St
Ir-192m	1 E−07	1 E−07	2 E−08	3 E+03	6 E+03	1 E+03	St/St/St
Ir-192	2 E−07	1 E−07	1 E−07	9 E+03	5 E+03	4 E+03	St/St/St
Ir-194m	8 E−08	8 E−08	6 E−08	3 E+03	3 E+03	2 E+03	St/St/St
Ir-194	1 E−06	7 E−07	7 E−07	5 E+04	2 E+04	2 E+04	St/St/St
Ir-195m	2 E−06	2 E−06	2 E−06	9 E+04	7 E+04	7 E+04	ET/ET/ET
Ir-195	7 E−06	5 E−06	4 E−06	2 E+05	1 E+05	1 E+05	ET/ET/ET
Pt-186	3 E−06	–	–	1 E+05	–	–	ET/ /
Pt-188	8 E−07	–	–	3 E+04	–	–	E/ /
Pt-189	3 E−06	–	–	1 E+05	–	–	ET/ /
Pt-191	1 E−06	–	–	7 E+04	–	–	ET/ /
Pt-193m	2 E−06	–	–	8 E+04	–	–	ET/ /
Pt-193	2 E−05	–	–	7 E+05	–	–	ET/ /
Pt-195m	1 E−06	–	–	5 E+04	–	–	ET/ /
Pt-197m	7 E−06	–	–	2 E+05	–	–	ET/ /
Pt-197	3 E−06	–	–	1 E+05	–	–	ET/ /
Pt-199	1 E−05	–	–	4 E+05	–	–	ET/ /
Pt-200	1 E−06	–	–	5 E+04	–	–	St/ /
Au-193	4 E−06	3 E−06	3 E−06	1 E+05	1 E+05	1 E+05	ET/E/St
Au-194	9 E−07	9 E−07	9 E−07	3 E+04	3 E+04	3 E+04	ET/ET/ET
Au-195	3 E−06	7 E−07	4 E−07	1 E+05	2 E+04	1 E+04	ET/St/St
Au-198m	6 E−07	2 E−07	2 E−07	2 E+04	1 E+04	1 E+04	ET/St/St
Au-198	1 E−06	5 E−07	5 E−07	4 E+04	2 E+04	1 E+04	ET/St/St
Au-199	2 E−06	8 E−07	7 E−07	7 E+04	3 E+04	2 E+04	ET/St/St
Au-200m	5 E−07	4 E−07	4 E−07	1 E+04	1 E+04	1 E+04	ET/ET/ET
Au-200	1 E−05	7 E−06	7 E−06	4 E+05	2 E+05	2 E+05	ET/ET/ET
Au-201	1 E−05	1 E−05	9 E−06	5 E+05	3 E+05	3 E+05	ET/ET/ET
Hg-193m (Org)	1 E−06	–	–	4 E+04	–	–	ET/ /
Hg-193m	1 E−06	1 E−06	–	4 E+04	4 E+04	–	ET/ET/
Hg-193m (Vapor).	–	1 E−07	–	–	6 E+03	–	/St/
Hg-193 (Org)	5 E−06	–	–	1 E+05	–	–	ET/ /
Hg-193	5 E−06	4 E−06	–	1 E+05	1 E+05	–	ET/ET/
Hg-193 (Vapor)	–	5 E−07	–	–	1 E+04	–	/St/
Hg-194 (Org)	2 E−08	–	–	1 E+03	–	–	St/ /
Hg-194	3 E−08	1 E−07	–	1 E+03	3 E+03	–	St/St/
Hg-194 (Vapor)	–	1 E−08	–	–	5 E+02	–	/St/
Hg-195m (Org)	1 E−06	–	–	5 E+04	–	–	ET/ /
Hg-195m	1 E−06	8 E−07	–	5 E+04	3 E+04	–	ET/St/
Hg-195m (Vapor).	–	6 E−08	–	–	2 E+03	–	/St/
Hg-195 (Org)	6 E−06	–	–	2 E+05	–	–	ET/ /
Hg-195	6 E−06	6 E−06	–	2 E+05	2 E+05	–	ET/ET/
Hg-195 (Vapor)	–	4 E−07	–	–	1 E+04	–	/St/
Hg-197m (Org)	1 E−06	–	–	5 E+04	–	–	ET/ /
Hg-197m	1 E−06	8 E−07	–	5 E+04	3 E+04	–	ET/St/
Hg-197m (Vapor).	–	9 E−08	–	–	3 E+03	–	/St/
Hg-197 (Org)	4 E−06	–	–	1 E+05	–	–	ET/ /
Hg-197	4 E−06	2 E−06	–	1 E+05	7 E+04	–	ET/St/
Hg-197 (Vapor)	–	1 E−07	–	–	4 E+03	–	/St/
Hg-199m (Org)	8 E−06	–	–	3 E+05	–	–	ET/ /

Radionuclide	Absorption type [3]			Absorption type [3]			Stochastic or organ or tissue [1]
	μCi/mL			Bq/m [3]			
	F	M	S	F	M	S	(F/M/S)
Hg-199m	8 E−06	5 E−06	–	3 E+05	1 E+05	–	ET/ET/
Hg-199m (Vapor).	–	3 E−06	–	–	1 E+05	–	/St/
Hg-203 (Org)	7 E−07	–	–	2 E+04	–	–	St/ /
Hg-203	9 E−07	2 E−07	–	3 E+04	1 E+04	–	St/St/
Hg-203 (Vapor)	–	8 E−08	–	–	2 E+03	–	/St/
Tl-194m	5 E−06	–	–	2 E+05	–	–	ET/ /
Tl-194	2 E−05	–	–	8 E+05	–	–	ET/ /
Tl-195	6 E−06	–	–	2 E+05	–	–	ET/ /
Tl-197	8 E−06	–	–	2 E+05	–	–	ET/ /
Tl-198m	2 E−06	–	–	9 E+04	–	–	ET/ /
Tl-198	1 E−06	–	–	5 E+04	–	–	ET/ /
Tl-199	5 E−06	–	–	2 E+05	–	–	ET/ /
Tl-200	8 E−07	–	–	3 E+04	–	–	ET/ /
Tl-201	4 E−06	–	–	1 E+05	–	–	ET/ /
Tl-202	1 E−06	–	–	5 E+04	–	–	ET/ /
Tl-204	9 E−07	–	–	3 E+04	–	–	St/ /
Pb-195m	7 E−06	–	–	2 E+05	–	–	ET/ /
Pb-198	2 E−06	–	–	9 E+04	–	–	ET/ /
Pb-199	4 E−06	–	–	1 E+05	–	–	ET/ /
Pb-200	1 E−06	–	–	4 E+04	–	–	ET/ /
Pb-201	2 E−06	–	–	7 E+04	–	–	ET/ /
Pb-202m	1 E−06	–	–	6 E+04	–	–	ET/ /
Pb-202	4 E−08	–	–	1 E+03	–	–	St/ /
Pb-203	2 E−06	–	–	7 E+04	–	–	ET/ /
Pb-205	9 E−07	–	–	3 E+04	–	–	BS/ /
Pb-209	9 E−06	–	–	3 E+05	–	–	ET/ /
Pb-210	1 E−10	–	–	5 E+00	–	–	BS/ /
Pb-211	4 E−08	–	–	1 E+03	–	–	ET/ /
Pb-212	5 E−09	–	–	2 E+02	–	–	ET/ /
Pb-214	4 E−08	–	–	1 E+03	–	–	ET/ /
Bi-200	5 E−06	4 E−06	–	2 E+05	1 E+05	–	ET/ET/
Bi-201	3 E−06	2 E−06	–	1 E+05	1 E+05	–	ET/ET/
Bi-202	2 E−06	2 E−06	–	9 E+04	9 E+04	–	ET/ET/
Bi-203	7 E−07	7 E−07	–	2 E+04	2 E+04	–	ET/ET/
Bi-205	4 E−07	4 E−07	–	1 E+04	1 E+04	–	ET/ET/
Bi-206	2 E−07	2 E−07	–	9 E+03	8 E+03	–	ET/ET/
Bi-207	4 E−07	1 E−07	–	1 E+04	6 E+03	–	ET/St/
Bi-210m	3 E−09	2 E−10	–	1 E+02	9 E+00	–	K/St/
Bi-210	1 E−07	9 E−09	–	6 E+03	3 E+02	–	K/St/
Bi-212	1 E−08	8 E−09	–	4 E+02	3 E+02	–	ET/ET/
Bi-213	1 E−08	7 E−09	–	4 E+02	2 E+02	–	ET/ET/
Bi-214	1 E−08	1 E−08	–	6 E+02	4 E+02	–	ET/ET/
Po-203	5 E−06	4 E−06	–	1 E+05	1 E+05	–	ET/ET/
Po-205	4 E−06	3 E−06	–	1 E+05	1 E+05	–	ET/ET/
Po-207	1 E−06	1 E−06	–	7 E+04	6 E+04	–	ET/ET/
Po-210	7 E−10	2 E−10	–	2 E+01	9 E+00	–	K/St/
At-207	1 E−06	2 E−07	–	4 E+04	1 E+04	–	St/St/
At-211	7 E−09	5 E−09	–	2 E+02	1 E+02	–	ET/St/
Rn-220 [5]	1 E−08	–	–	6 E+02	–	–	–
Rn-222 [5]	8 E−08	–	–	3 E+03	–	–	–
Fr-222	1 E−08	–	–	3 E+02	–	–	ET/ /
Fr-223	4 E−07	–	–	1 E+04	–	–	St/ /
Ra-223	–	9 E−11	–	–	3 E+00	–	/St/
Ra-224	–	2 E−10	–	–	8 E+00	–	/St/
Ra-225	–	1 E−10	–	–	4 E+00	–	/St/
Ra-226	–	2 E−10	–	–	9 E+00	–	/St/
Ra-227	–	8 E−07	–	–	3 E+04	–	/BS/
Ra-228	–	1 E−10	–	–	5 E+00	–	/BS/
Ac-224	1 E−08	6 E−09	5 E−09	6 E+02	2 E+02	2 E+02	BS/St/St
Ac-225	2 E−10	9 E−11	8 E−11	7 E+00	3 E+00	3 E+00	BS/St/St
Ac-226	1 E−09	6 E−10	5 E−10	4 E+01	2 E+01	2 E+01	ET/St/St
Ac-227	2 E−13	1 E−12	1 E−11	1 E−02	5 E−02	4 E−01	BS/BS/St
Ac-228	6 E−09	3 E−08	4 E−08	2 E+02	1 E+03	1 E+03	BS/BS/St
Th-226	–	4 E−09	4 E−09	–	1 E+02	1 E+02	/ET/ET
Th-227	–	9 E−11	7 E−11	–	3 E+00	2 E+00	/St/St
Th-228	–	2 E−11	2 E−11	–	7 E−01	8 E−01	/BS/St
Th-229	–	2 E−12	1 E−11	–	7 E−02	4 E−01	/BS/St
Th-230	–	3 E−12	4 E−11	–	1 E−01	1 E+00	/BS/BS
Th-231	–	1 E−06	1 E−06	–	5 E+04	5 E+04	/St/St
Th-232	–	3 E−12	4 E−11	–	1 E−01	1 E+00	/BS/BS

Radionuclide	Absorption type [3]			Absorption type [3]			Stochastic or organ or tissue [1]
	μCi/mL			Bq/m [3]			
	F	M	S	F	M	S	(F/M/S)
Th-234	–	1 E−07	9 E−08	–	3 E+03	3 E+03	/St/St
Pa-227	–	4 E−09	4 E−09	–	1 E+02	1 E+02	/ET/ET
Pa-228	–	1 E−08	1 E−08	–	3 E+02	4 E+02	/BS/St
Pa-230	–	1 E−09	9 E−10	–	4 E+01	3 E+01	/St/St
Pa-231	–	1 E−12	1 E−11	–	4 E−02	4 E−01	/BS/BS
Pa-232	–	1 E−08	1 E−07	–	6 E+02	7 E+03	/BS/BS
Pa-233	–	2 E−07	1 E−07	–	7 E+03	6 E+03	/St/St
Pa-234	–	7 E−07	7 E−07	–	2 E+04	2 E+04	/ET/ET
U-230	6 E−10	5 E−11	4 E−11	2 E+01	2 E+00	1 E+00	K/St/St
U-231	2 E−06	1 E−06	1 E−06	8 E+04	4 E+04	4 E+04	ET/St/St
U-232	5 E−11	1 E−10	2 E−11	2 E+00	4 E+00	7 E−01	BS/St/ET
U-233	4 E−10	2 E−10	7 E−11	1 E+01	9 E+00	2 E+00	BS/St/ET
U-234	5 E−10	2 E−10	7 E−11	1 E+01	9 E+00	2 E+00	BS/St/ET
U-235	5 E−10	3 E−10	8 E−11	1 E+01	1 E+01	3 E+00	BS/St/ET
U-236	5 E−10	2 E−10	7 E−11	1 E+01	1 E+01	2 E+00	BS/St/ET
U-237	1 E−06	3 E−07	3 E−07	4 E+04	1 E+04	1 E+04	ET/St/St
U-238	5 E−10	3 E−10	8 E−11	2 E+01	1 E+01	3 E+00	BS/St/ET
U-239	1 E−05	9 E−06	9 E−06	5 E+05	3 E+05	3 E+05	ET/ET/ET
U-240	1 E−06	7 E−07	6 E−07	5 E+04	2 E+04	2 E+04	ET/St/St
Np-232	–	3 E−06	–	–	1 E+05	–	/BS/
Np-233	–	7 E−05	–	–	2 E+06	–	/ET/
Np-234	–	5 E−07	–	–	2 E+04	–	/ET/
Np-235	–	1 E−06	–	–	4 E+04	–	/BS/
Np-236 (1 E+05 yr).	–	4 E−11	–	–	1 E+00	–	/BS/
Np-236 (22 h)	–	5 E−08	–	–	1 E+03	–	/BS/
Np-237	–	8 E−12	–	–	3 E−01	–	/BS/
Np-238	–	1 E−07	–	–	4 E+03	–	/BS/
Np-239	–	5 E−07	–	–	1 E+04	–	/St/
Np-240	–	2 E−06	–	–	8 E+04	–	/ET/
Pu-234	–	3 E−08	3 E−08	–	1 E+03	1 E+03	/St/St
Pu-235	–	9 E−05	8 E−05	–	3 E+06	3 E+06	/ET/ET
Pu-236	–	1 E−11	7 E−11	–	6 E−01	2 E+00	/BS/St
Pu-237	–	1 E−06	1 E−06	–	7 E+04	6 E+04	/St/St
Pu-238	–	6 E−12	5 E−11	–	2 E−01	1 E+00	/BS/St
Pu-239	–	5 E−12	6 E−11	–	2 E−01	2 E+00	/BS/BS
Pu-240	–	5 E−12	6 E−11	–	2 E−01	2 E+00	/BS/BS
Pu-241	–	2 E−10	2 E−09	–	1 E+01	1 E+02	/BS/BS
Pu-242	–	5 E−12	6 E−11	–	2 E−01	2 E+00	/BS/BS
Pu-243	–	5 E−06	5 E−06	–	1 E+05	1 E+05	/E/E
Pu-244	–	5 E−12	6 E−11	–	2 E−01	2 E+00	/BS/BS
Pu-245	–	9 E−07	8 E−07	–	3 E+04	3 E+04	/St/St
Pu-246	–	8 E−08	8 E−08	–	3 E+03	2 E+03	/St/St
Am-237	–	8 E−06	–	–	3 E+05	–	/ET/
Am-238	–	2 E−06	–	–	9 E+04	–	/BS/
Am-239	–	1 E−06	–	–	6 E+04	–	/ET/
Am-240	–	7 E−07	–	–	2 E+04	–	/ET/
Am-241	–	5 E−12	–	–	1 E−01	–	/BS/
Am-242m	–	5 E−12	–	–	1 E−01	–	/BS/
Am-242	–	4 E−08	–	–	1 E+03	–	/St/
Am-243	–	5 E−12	–	–	1 E−01	–	/BS/
Am-244m	–	3 E−06	–	–	1 E+05	–	/BS/
Am-244	–	1 E−07	–	–	5 E+03	–	/BS/
Am-245	–	5 E−06	–	–	2 E+05	–	/ET/
Am-246m	–	6 E−06	–	–	2 E+05	–	/ET/
Am-246	–	2 E−06	–	–	9 E+04	–	/ET/
Cm-238	–	1 E−07	–	–	4 E+03	–	/St/
Cm-240	–	2 E−10	–	–	7 E+00	–	/St/
Cm-241	–	2 E−08	–	–	8 E+02	–	/St/
Cm-242	–	1 E−10	–	–	5 E+00	–	/St/
Cm-243	–	7 E−12	–	–	2 E−01	–	/BS/
Cm-244	–	9 E−12	–	–	3 E−01	–	/BS/
Cm-245	–	5 E−12	–	–	1 E−01	–	/BS/
Cm-246	–	5 E−12	–	–	1 E−01	–	/BS/
Cm-247	–	5 E−12	–	–	2 E−01	–	/BS/
Cm-248	–	1 E−12	–	–	5 E−02	–	/BS/
Cm-249	–	8 E−06	–	–	3 E+05	–	/ET/
Cm-250	–	2 E−13	–	–	8 E−03	–	/BS/
Bk-245	–	3 E−07	–	–	1 E+04	–	/St/
Bk-246	–	8 E−07	–	–	3 E+04	–	/ET/
Bk-247	–	3 E−12	–	–	1 E−01	–	/BS/

Radionuclide	Absorption type [3]			Absorption type [3]			Stochastic or organ or tissue [1]
	μCi/mL			Bq/m [3]			
	F	M	S	F	M	S	(F/M/S)
Bk-249	–	1 E−09	–	–	5 E+01	–	/BS/
Bk-250	–	2 E−07	–	–	9 E+03	–	/BS/
Cf-244	–	1 E−08	–	–	5 E+02	–	/ET/
Cf-246	–	1 E−09	–	–	5 E+01	–	/St/
Cf-248	–	5 E−11	–	–	2 E+00	–	/BS/
Cf-249	–	3 E−12	–	–	1 E−01	–	/BS/
Cf-250	–	7 E−12	–	–	2 E−01	–	/BS/
Cf-251	–	3 E−12	–	–	1 E−01	–	/BS/
Cf-252	–	1 E−11	–	–	6 E−01	–	/BS/
Cf-253	–	5 E−10	–	–	2 E+01	–	/St/
Cf-254	–	2 E−11	–	–	8 E−01	–	/BS/
Es-250	–	4 E−07	–	–	1 E+04	–	/BS/
Es-251	–	3 E−07	–	–	1 E+04	–	/St/
Es-253	–	2 E−10	–	–	9 E+00	–	/St/
Es-254m	–	1 E−09	–	–	5 E+01	–	/St/
Es-254	–	6 E−11	–	–	2 E+00	–	/BS/
Fm-252	–	2 E−09	–	–	8 E+01	–	/St/
Fm-253	–	1 E−09	–	–	6 E+01	–	/St/
Fm-254	–	6 E−09	–	–	2 E+02	–	/ET/
Fm-255	–	2 E−09	–	–	8 E+01	–	/St/
Fm-257	–	1 E−10	–	–	4 E+00	–	/St/
Md-257	–	2 E−08	–	–	1 E+03	–	/St/
Md-258	–	1 E−10	–	–	4 E+00	–	/St/

FOOTNOTES FOR APPENDIX A

[1] A determination of whether the DACs are controlled by stochastic (St) or deterministic (organ or tissue) dose, or if they both give the same result (E), for each absorption type, is given in this column. The key to the organ notation for deterministic dose is: BS = Bone surface, ET = Extrathoracic, K = Kidney, L = Liver, and T = Thyroid. A blank indicates that no calculations were performed for the absorption type shown.

[2] The ICRP identifies these materials as soluble or reactive gases and vapors or highly soluble or reactive gases and vapors. For tritiated water, the inhalation DAC values allow for an additional 50% absorption through the skin, as described in ICRP Publication No. 68, Dose Coefficients for Intakes of Radionuclides by Workers. For elemental tritium, the DAC values include a factor that irradiation from gas within the lungs might increase the dose by 20%.

[3] A dash indicates no values given for this data category.

[4] DAC values derived using hafnium tritide particle and are based on ''observed activity'' (i.e, only radiation emitted from the particle is considered). DAC values derived using methodology found in Radiological Control Programs for Special Tritium Compounds, DOE–HDBK–1184–2004.

[5] These values are appropriate for protection from radon combined with its short-lived decay products and are based on information given in ICRP Publication 65: Protection Against Radon-222 at Home and at Work and in DOE–STD–1121–98: Internal Dosimetry. The values given are for 100% equilibrium concentration conditions of the short-lived radon decay products with the parent. To allow for an actual measured equilibrium concentration or a demonstrated equilibrium concentration, the values given in this table should be multiplied by the ratio (100%/actual %) or (100%/demonstrated %), respectively. Alternatively, the DAC values for Rn-220 and Rn-222 may be replaced by 2.5 working level (WL) and 0.83 WL, respectively, for appropriate limiting of decay product concentrations. A WL is any combination of short-lived radon decay products, in one liter of air without regard to the degree of equilibrium, that will result in the ultimate emission of 1.3 E+05 MeV of alpha energy.

[72 FR 31927, June 8, 2007]

APPENDIX B TO PART 835 [RESERVED]

APPENDIX C TO PART 835—DERIVED AIR CONCENTRATION (DAC) FOR WORKERS FROM EXTERNAL EXPOSURE DURING IMMERSION IN A CLOUD OF AIRBORNE RADIOACTIVE MATERIAL

a. The data presented in appendix C are to be used for controlling occupational exposures in accordance with §835.209, identifying the need for air monitoring in accordance with §835.403 and identifying the need for posting of airborne radioactivity areas in accordance with §835.603(d).

b. The air immersion DAC values shown in this appendix are based on a stochastic dose

limit of 5 rems (0.05 Sv) per year. Four columns of information are presented: (1) Radionuclide; (2) half-life in units of seconds (s), minutes (min), hours (h), days (d), or years (yr); (3) air immersion DAC in units of μCi/mL; and (4) air immersion DAC in units of Bq/m3. The data are listed by radionuclide in order of increasing atomic mass. The air immersion DACs were calculated for a continuous, nonshielded exposure via immersion in a semi-infinite cloud of airborne radioactive material. The DACs listed in this appendix may be modified to allow for submersion in a cloud of finite dimensions.

c. The DAC values are given for individual radionuclides. For known mixtures of radionuclides, determine the sum of the ratio of the observed concentration of a particular radionuclide and its corresponding DAC for all radionuclides in the mixture. If this sum exceeds unity (1), then the DAC has been exceeded. For unknown radionuclides, the most restrictive DAC (lowest value) for those isotopes not known to be absent shall be used.

AIR IMMERSION DAC

Air immersion DAC			
Radionuclide	Half-Life	(μCi/mL)	(Bq/m^3)
Ar-37	35.02 d	1 E+00	4 E+10
Ar-39	269 yr	4 E–04	1 E+07
Ar-41	1.827 h	1 E–06	3 E+04
Kr-74	11.5 min	1 E–06	4 E+04
Kr-76	14.8 h	3 E–06	1 E+05
Kr-77	74.7 h	1 E–06	5 E+04
Kr-79	35.04 h	5 E–06	2 E+05
Kr-81	2.1E+05 yr	2 E–04	9 E+06
Kr-83m	1.83 h	2 E–02	9 E+08
Kr-85	10.72 yr	2 E–04	9 E+06
Kr-85m	4.48 h	9 E–06	3 E+05
Kr-87	76.3 min	1 E–06	5 E+04
Kr-88	2.84 h	6 E–07	2 E+04
Xe-120	40.0 min	3 E–06	1 E+05
Xe-121	40.1 min	7 E–07	2 E+04
Xe-122	20.1 h	2 E–05	1 E+06
Xe-123	2.14 h	2 E–06	8 E+04
Xe-125	16.8 h	5 E–06	2 E+05
Xe-127	36.406 d	5 E–06	2 E+05
Xe-129m	8.89 d	6 E–05	2 E+06
Xe-131m	11.84 d	1 E–04	6 E+06
Xe-133	5.245 d	4 E–05	1 E+06
Xe-133m	2.19 d	4 E–05	1 E+06
Xe-135	9.11 h	5 E–06	2 E+05
Xe-135m	15.36 min	3 E–06	1 E+05
Xe-138	14.13 min	1 E–06	4 E+04

For any single radionuclide not listed above with decay mode other than alpha emission or spontaneous fission and with radioactive half-life less than two hours, the DAC value shall be 6 E–06 μCi/mL (2 E+04 Bq/m^3).

[72 FR 31940, June 8, 2007]

APPENDIX D TO PART 835—SURFACE CONTAMINATION VALUES

The data presented in appendix D are to be used in identifying the need for posting of contamination and high contamination areas in accordance with §835.603(e) and (f) and identifying the need for surface contamination monitoring and control in accordance with §§835.1101 and 835.1102.

SURFACE CONTAMINATION VALUES[1] IN DPM/100 CM[2]

Radionuclide	Removable[2,4]	Total (Fixed + Removable)[2,3]
U-nat, U-235, U-238, and associated decay products	[7]1,000	[7]5,000
Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129	20	500
Th-nat, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133	200	1,000
Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above[5]	1,000	5,000

SURFACE CONTAMINATION VALUES [1] IN DPM/100 CM [2]—Continued

Radionuclide	Removable [2] [4]	Total (Fixed + Removable) [2], [3]
Tritium and STCs [6]	10,000	See Footnote 6

[1] The values in this appendix, with the exception noted in footnote 5, apply to radioactive contamination deposited on, but not incorporated into the interior or matrix of, the contaminated item. Where surface contamination by both alpha-and beta-gamma-emitting nuclides exists, the limits established for alpha-and beta-gamma-emitting nuclides apply independently.

[2] As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

[3] The levels may be averaged over one square meter provided the maximum surface activity in any area of 100 cm [2] is less than three times the value specified. For purposes of averaging, any square meter of surface shall be considered to be above the surface contamination value if: (1) From measurements of a representative number of sections it is determined that the average contamination level exceeds the applicable value; or (2) it is determined that the sum of the activity of all isolated spots or particles in any 100 cm [2] area exceeds three times the applicable value.

[4] The amount of removable radioactive material per 100 cm [2] of surface area should be determined by swiping the area with dry filter or soft absorbent paper, applying moderate pressure, and then assessing the amount of radioactive material on the swipe with an appropriate instrument of known efficiency. (Note—The use of dry material may not be appropriate for tritium.) When removable contamination on objects of surface area less than 100 cm [2] is determined, the activity per unit area shall be based on the actual area and the entire surface shall be wiped. It is not necessary to use swiping techniques to measure removable contamination levels if direct scan surveys indicate that the total residual surface contamination levels are within the limits for removable contamination.

[5] This category of radionuclides includes mixed fission products, including the Sr-90 which is present in them. It does not apply to Sr-90 which has been separated from the other fission products or mixtures where the Sr-90 has been enriched.

[6] Tritium contamination may diffuse into the volume or matrix of materials. Evaluation of surface contamination shall consider the extent to which such contamination may migrate to the surface in order to ensure the surface contamination value provided in this appendix is not exceeded. Once this contamination migrates to the surface, it may be removable, not fixed; therefore, a ''Total'' value does not apply. In certain cases, a ''Total'' value of 10,000 dpm/100 cm [2] may be applicable either to metals, of the types which form insoluble special tritium compounds that have been exposed to tritium; or to bulk materials to which particles of insoluble special tritium compound are fixed to a surface.

[7] These limits only apply to the alpha emitters within the respective decay series.

[58 FR 65485, Dec. 14, 1993, as amended at 63 FR 59688, Nov. 4, 1998; 72 FR 31940, June 8, 2007]

APPENDIX E TO PART 835—VALUES FOR ESTABLISHING SEALED RADIOACTIVE SOURCE ACCOUNTABILITY AND RADIOACTIVE MATERIAL POSTING AND LABELING REQUIREMENTS

The data presented in appendix E are to be used for identifying accountable sealed radioactive sources and radioactive material areas as those terms are defined at §835.2(a), establishing the need for radioactive material area posting in accordance with §835.603(g), and establishing the need for radioactive material labeling in accordance with §835.605.

Nuclide	Activity (μCi)
H-3	1.5E+08
Be-7	3.1E+03
Be-10	1.4E+05
C-14	4.6E+06
Na-22	1.9E+01
Al-26	1.5E+01
Si-32	4.9E+04
S-35	2.4E+06
Cl-36	5.2E+05
K-40	2.7E+02
Ca-41	9.3E+06
Ca-45	1.1E+06
Sc-46	6.2E+01
Ti-44	1.5E+02
V-49	1.0E+08
Mn-53	7.5E+07
Mn-54	6.5E+01
Fe-55	2.9E+06
Fe-59	1.9E+02
Fe-60	8.1E+03
Co-56	3.9E+01
Co-57	2.3E+02
Co-58	1.3E+02
Co-60	1.7E+01
Ni-59	3.2E+06
Ni-63	1.3E+06
Zn-65	1.1E+02
Ge-68	5.6E+02
As-73	5.3E+02
Se-75	6.3E+01
Se-79	8.7E+05
Rb-83	9.1E+01
Rb-84	2.0E+02
Sr-85	1.2E+02
Sr-89	4.8E+05
Sr-90	3.5E+04
Y-88	3.3E+01
Y-91	5.0E+04
Zr-88	1.1E+02
Zr-93	9.3E+04
Zr-95	1.9E+02
Nb-91	6.9E+01
Nb-91m	3.6E+02
Nb-92	1.8E+01
Nb-93m	4.4E+02
Nb-94	2.3E+01
Nb-95	3.4E+02
Mo-93	7.7E+01
Tc-95m	1.3E+02
Tc-97	8.1E+01
Tc-97m	3.5E+02
Tc-98	2.5E+01
Tc-99	8.4E+05
Ru-103	4.4E+02
Ru-106	2.5E+02
Rh-101	8.7E+05
Rh-102	3.0E+05

Nuclide	Activity (μCi)
Rh-102m	6.4E+05
Pd-107	9.3E+06
Ag-105	3.3E+06
Ag-108m	1.8E+01
Ag-110m	2.2E+01
Cd-109	1.6E+02
Cd-113m	2.0E+04
Cd-115m	1.0E+04
In-114m	7.7E+02
Sn-113	3.1E+02
Sn-119m	3.3E+02
Sn-121m	8.1E+05
Sn-123	1.3E+04
Sn-126	1.8E+02
Sb-124	9.1E+01
Sb-125	6.7E+01
Te-121m	1.8E+02
Te-123m	2.8E+02
Te-125m	4.4E+02
Te-127m	8.0E+02
Te-129m	2.3E+03
I-125	3.5E+02
I-129	1.8E+02
Cs-134	2.6E+01
Cs-135	1.3E+06
Cs-137	6.0E+01
Ba-133	5.1E+01
La-137	2.7E+05
Ce-139	2.4E+02
Ce-141	2.4E+03
Ce-144	1.4E+03
Pm-143	1.3E+02
Pm-144	2.9E+01
Pm-145	2.6E+02
Pm-146	4.4E+01
Pm-147	7.7E+05
Pm-148m	1.0E+02
Sm-145	2.4E+06
Sm-146	4.0E+02
Sm-151	2.5E+05
Eu-148	1.1E+06
Eu-149	1.1E+07
Eu-152	3.1E+01
Eu-154	3.1E+01
Eu-155	3.6E+02
Gd-146	5.1E+05
Gd-148	9.0E+01
Gd-151	2.9E+06
Gd-153	2.1E+02
Tb-157	2.5E+03
Tb-158	9.0E+04
Tb-160	1.2E+02
Dy-159	1.0E+07
Ho-166m	2.1E+01
Tm-170	8.4E+03
Tm-171	2.8E+04
Yb-169	5.5E+02
Lu-173	1.8E+06
Lu-174	9.3E+05
Lu-174m	1.0E+06
Lu-177m	5.8E+01
Hf-172	7.3E+04
Hf-175	3.0E+06
Hf-178m	8.7E+03
Hf-181	3.4E+02
Hf-182	7.5E+03
Ta-179	9.3E+06
Ta-182	7.3E+01
W-181	1.0E+03
W-185	3.9E+06
W-188	6.3E+04
Re-183	5.3E+02
Re-184	2.6E+02
Re-184m	1.5E+02
Re-186m	3.4E+05
Os-185	1.3E+02
Os-194	6.4E+04
Ir-192	1.3E+02
Ir-192m	1.4E+05
Ir-194m	2.7E+01
Pt-193	8.7E+07
Au-195	4.8E+02
Hg-194	5.2E+04
Hg-203	4.9E+02
Tl-204	2.2E+04
Pb-202	1.9E+05
Pb-205	9.0E+01
Pb-210	9.2E+01
Bi-207	1.7E+01
Bi-208	1.5E+01
Bi-210m	1.2E+03
Po-209	6.3E+03
Po-210	1.2E+03
Ra-226	2.2E+02
Ra-228	1.5E+03
Ac-227	4.2E+00
Th-228	8.4E+01
Th-229	3.1E+01
Th-230	5.4E+00
Th-232	9.3E+01
Pa-231	3.0E+01
U-232	1.0E+02
U-233	3.9E+02
U-234	2.9E+02
U-235	6.7E+01
U-236	3.1E+02
U-238	3.5E+02
Np-235	1.1E+02
Np-236	2.1E+01
Np-237	4.9E+01
Pu-236	2.0E+02
Pu-237	3.3E+02
Pu-238	9.0E+01
Pu-239	8.4E+01
Pu-240	8.4E+01
Pu-241	4.6E+03
Pu-242	8.7E+01
Pu-244	9.0E+01
Am-241	7.2E+01
Am-242m	1.1E+02
Am-243	7.3E+01
Cm-241	1.0E+05
Cm-242	6.2E+02
Cm-243	4.8E+01
Cm-244	1.5E+02
Cm-245	5.0E+01
Cm-246	1.0E+02
Cm-247	8.5E+01
Cm-248	2.8E+01
Cm-250	5.4E+00
Bk-247	6.0E+01
Bk-249	2.7E+04
Cf-248	4.4E+02
Cf-249	5.5E+01
Cf-250	1.2E+02
Cf-251	5.3E+01
Cf-252	5.2E+00
Cf-254	1.2E+02
Es-254	6.3E+01
Es-255	8.8E+03
Fm-257	5.1E+02
Md-258	6.1E+02

Any alpha emitting radionuclide not listed in appendix E and mixtures of alpha emitters of unknown composition have a value of 10 μCi.

With the exception that any type of STC has a value of 10 Ci, any radionuclide other than alpha emitting radionuclides not listed in appendix E and mixtures of beta emitters of unknown composition have a value of 100 μCi.

NOTE: Where there is involved a mixture of radionuclides in known amounts, derive the value for the mixture as follows: determine, for each radionuclide in the mixture, the ratio between the quantity present in the mixture and the value otherwise established for the specific radionuclide when not in the mixture. If the sum of such ratios for all radionuclides in the mixture exceeds unity (1), then the accountability criterion has been exceeded.

[72 FR 31940, June 8, 2007]

PART 840—EXTRAORDINARY NUCLEAR OCCURRENCES

Sec.

840.1 Scope and purpose.
840.2 Procedures.
840.3 Determination of extraordinary nuclear occurrence.
840.4 Criterion I—Substantial discharge of radioactive material or substantial radiation levels offsite.
840.5 Criterion II—Substantial damages to persons offsite or property offsite.

AUTHORITY: Sec. 161 of the Atomic Energy Act of 1954, Pub. L. 83–703, 68 Stat. 919 (42 U.S.C. 2201); sec. 170 of the Atomic Energy Act of 1954, Pub. L. 85–256, 71 Stat. 576, as amended by Pub. L. 89–645, 80 Stat. 891 (42 U.S.C. 2210); Department of Energy Organization Act, Pub. L. 95–91, 91 Stat. 565–613 (42 U.S.C. 7101–7352).

SOURCE: 49 FR 21473, May 21, 1984, unless otherwise noted.

§ 840.1 Scope and purpose.

(a) *Scope.* This subpart applies to those DOE contractor activities to which the nuclear hazards indemnity provisions in 41 CFR 9–50.704–6 apply, and to other persons indemnified with respect to such activities.

(b) *Purpose.* One purpose of this subpart is to set forth the criteria which the DOE proposes to follow in order to determine whether there has been an ''extraordinary nuclear occurrence.'' The other purpose is to establish the conditions of the waivers of defenses proposed for incorporation in indemnity agreements.

(1) The system is to come into effect only where the discharge or dispersal constitutes a substantial amount of source, special nuclear or byproduct material, or has caused substantial radiation levels offsite. The various limits in present DOE regulations are not appropriate for direct application in the determination of an ''extraordinary nuclear occurrence,'' for they were arrived at with other purposes in mind, and those limits have been set at a level which is conservatively arrived at by incorporating a significant safety factor. Thus, a discharge or dispersal which exceeds the limits in DOE regulations, or in DOE orders, although possible cause for concern, is not one which would be expected to cause substantial injury or damage unless it exceeds by some significant multiple the appropriate regulatory limit. Accordingly, in arriving at the values in the criteria to be deemed ''substantial'' it is more appropriate to adopt values separate from DOE health and safety orders, and, of course the selection of these values will not in any way affect such orders. A substantial discharge, for purposes of the criteria, represents a perturbation of the environment which is clearly above that which could be anticipated from the conduct of normal activities. The criteria are intended solely for the purposes of administration of DOE statutory responsibilities under Pub. L. 89–645, and are not intended to indicate a level of discharge or dispersal at which damage is likely to occur, or even a level at which some type of protective action is indicated. It should be clearly understood that the criteria in no way establish or indicate that there is a specific threshold of exposure at which biological damage from radiation will take place. It cannot be emphasized too frequently that the levels set to be used as criteria for the first part of the determination, that is, the criteria for amounts offsite or radiation levels offsite which are substantial, are not meant to indicate that, because such amounts or levels are determined to be substantial for purposes of administration, they are ''substantial'' in terms of their propensity for causing injury or damage.

(2) It is the purpose of the second part of the determination that DOE decide whether there have in fact been or will probably be substantial damages