

CHAPTER 40  
STANDARDS FOR PROTECTION AGAINST RADIATION

GENERAL PROVISIONS

**641—40.1(136C) Purpose and scope.**

**40.1(1)** This chapter establishes standards for protection against ionizing radiation resulting from activities conducted pursuant to licenses or registrations issued by the agency. These rules are issued pursuant to the authority in Iowa Code section 136C.3 and 136C.4.

**40.1(2)** The requirements of this chapter are designed to control the receipt, possession, use, transfer, and disposal of sources of radiation by any licensee or registrant so the total dose to an individual, including doses resulting from all sources of radiation other than background radiation, does not exceed the standards for protection against radiation prescribed in this chapter. However, nothing in this chapter shall be construed as limiting actions that may be necessary to protect health and safety.

**40.1(3)** In addition to complying with the requirements set forth in this chapter, every reasonable effort should be made to maintain radiation exposures and releases of radioactive material in effluents to unrestricted areas as low as is reasonably achievable (ALARA). The term “as low as is reasonably achievable” means as low as is reasonably achievable taking into account the state of technology and the economics of improvements in relation to benefits to the public health and safety, other societal and socioeconomic considerations, and in relation to the utilization of ionizing radiation in the public interest.

**40.1(4)** Except as specifically provided in other parts of these rules, this chapter applies to persons licensed or registered by the agency to receive, possess, use, transfer, or dispose of sources of radiation. The limits in this chapter do not apply to doses due to background radiation, to exposure of patients to radiation for the purpose of medical diagnosis or therapy, or to voluntary participation in medical research programs.

**40.1(5)** All references to Code of Federal Regulations (CFR) in this chapter are those in effect on or before July 9, 2008.

**40.1(6)** The provisions of Chapter 40 are in addition to, and not in substitution for, any other applicable portions of 641—Chapters 38 to 45.

**641—40.2(136C) Definitions.**

**40.2(1)** For the purposes of this chapter, the definitions of 641—Chapter 38 may also apply.

**40.2(2)** As used in this chapter, these terms have the definitions set forth below.

“*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 person that would result in a committed effective dose equivalent of 5 rem (0.05 Sv) or a committed dose equivalent of 50 rem (0.5 Sv) to any individual organ or tissue. ALI values for intake by ingestion and by inhalation of selected radionuclides are given in Table I, Columns 1 and 2, of Appendix B.

“*Class (or lung class or inhalation class)*” means a classification scheme for inhaled material according to its rate of clearance from the pulmonary region of the lung. Materials are classified as D, W, or Y, which applies to a range of clearance half-times: for Class D, Days, of less than 10 days, for Class W, Weeks, from 10 to 100 days, and for Class Y, Years, of greater than 100 days.

“*Declared pregnant woman*” means a woman who has voluntarily informed her licensee or registrant, in writing, of her pregnancy and the estimated date of conception. The declaration remains in effect until the declared pregnant woman withdraws the declaration in writing or is no longer pregnant.

“*Derived air concentration (DAC)*” means the concentration of a given radionuclide in air which, if breathed by the reference person for a working year of 2,000 hours under conditions of light work (inhalation rate 1.2 cubic meters of air per hour) results in an intake of one ALI. DAC values are given in Table I, Column 3, of Appendix B.

“*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 derived air concentration for each

radionuclide, and the time of exposure to that radionuclide, in hours. A licensee or registrant may take 2,000 DAC-hours to represent one ALI, equivalent to a committed dose equivalent of 5 rem (0.05 Sv).

*“Dosimetry processor”* means an individual or an organization that processes and evaluates individual monitoring devices in order to determine the radiation dose delivered to the monitoring devices.

*“Inhalation class”* (see “Class.”)

*“Lung class”* (see “Class.”)

*“National tracked source”* means a sealed source containing a quantity equal to or greater than Category 1 or Category 2 levels of any radioactive material listed in Appendix H of this chapter. In this context a “sealed source” is defined as radioactive material that is sealed in a capsule or closely bonded in a solid form and that is not exempt from regulatory control. It does not mean material encapsulated solely for disposal, or nuclear material contained in any fuel assembly, subassembly, fuel rod, or fuel pellet. Category 1 nationally tracked sources are those containing radioactive material at a quantity equal to or greater than the Category 1 threshold. Category 2 nationally tracked sources are those containing radioactive material at a quantity equal to or greater than the Category 2 threshold but less than the Category 1 threshold.

*“Nonstochastic effect”* means a health effect, the severity of which varies with the dose and for which a threshold is believed to exist. Radiation-induced cataract formation is an example of a nonstochastic effect. For purposes of these rules, “deterministic effect” is an equivalent term.

*“Planned special exposure”* means an infrequent exposure to radiation, separate from and in addition to the annual occupational dose limits.

*“Quarter”* means a period of time equal to one-fourth of the year observed by the licensee, approximately 13 consecutive weeks, providing that the beginning of the first quarter in a year coincides with the starting date of the year and that no day is omitted or duplicated in consecutive quarters.

*“Reference person”* means a hypothetical aggregation of human physical and physiological characteristics determined by international consensus. These characteristics may be used by researchers and public health workers to standardize results of experiments and to relate biological insult to a common base. A description of the reference person is contained in the International Commission on Radiological Protection report, ICRP Publication 23, “Report of the Task Group on Reference Man.”

*“Respiratory protective equipment”* means an apparatus, such as a respirator, used to reduce an individual’s intake of airborne radioactive materials.

*“Sanitary sewerage”* means a system of public sewers for carrying off wastewater and refuse, but excluding sewage treatment facilities, septic tanks, and leach fields owned or operated by the licensee or registrant.

*“Stochastic effect”* means a health effect that occurs randomly and for which the probability of the effect occurring, rather than its severity, is assumed to be a linear function of dose without threshold. Hereditary effects and cancer incidence are examples of stochastic effects. For purposes of these rules, “probabilistic effect” is an equivalent term.

*“Weighting factor”*  $w_T$  for an organ or tissue (T) means the proportion of the risk of stochastic effects resulting from irradiation of that organ or tissue to the total risk of stochastic effects when the whole body is irradiated uniformly. For calculating the effective dose equivalent, the values of  $w_T$  are:

ORGAN DOSE WEIGHTING FACTORS	
Organ or Tissue	$w_T$
Gonads	0.25
Breast	0.15
Red bone marrow	0.12
Lung	0.12
Thyroid	0.03
Bone surfaces	0.03

ORGAN DOSE WEIGHTING FACTORS

Organ or Tissue	$w_T$
Remainder	0.30 <sup>a</sup>
Whole Body	1.00 <sup>b</sup>

<sup>a</sup>0.30 results from 0.06 for each of 5 “remainder” organs, excluding the skin and the lens of the eye, that receive the highest doses.

<sup>b</sup>For the purpose of weighting the external whole body dose, for adding it to the internal dose, a single weighting factor,  $w_T = 1.0$ , has been specified. The use of other weighting factors for external exposure will be approved on a case-by-case basis until such time as specific guidance is issued.

**641—40.3(136C) Implementation.**

**40.3(1)** Any existing license or registration condition that is more restrictive than this chapter remains in force until there is an amendment or renewal of the license or registration.

**40.3(2)** If a license or registration condition exempts a licensee or registrant from a provision of this chapter in effect on or before January 1, 1994, it also exempts the licensee or registrant from the corresponding provision of this chapter.

**40.3(3)** If a license or registration condition cites provisions of this chapter in effect prior to January 1, 1994, which do not correspond to any provisions of this chapter, the license or registration condition remains in force until there is an amendment or renewal of the license or registration that modifies or removes this condition.

**641—40.4 to 40.9** Reserved.

RADIATION PROTECTION PROGRAMS

**641—40.10(136C) Radiation protection programs.**

**40.10(1)** Each licensee or registrant shall develop, document, and implement a radiation protection program sufficient to ensure compliance with the provisions of this chapter. See 40.81(136C) for record-keeping requirements relating to these programs.

**40.10(2)** The licensee or registrant shall use, to the extent practical, procedures and engineering controls based upon sound radiation protection principles to achieve occupational doses and public doses that are as low as is reasonably achievable (ALARA).

**40.10(3)** The licensee or registrant shall, at intervals not to exceed 12 months, review the radiation protection program content and implementation.

**40.10(4)** To implement the ALARA requirements of 40.10(2), and notwithstanding the requirements in 641—40.26(136C), a constraint on air emissions of radioactive material to the environment, excluding radon-222 and its daughters, shall be established by licensees such that the individual member of the public likely to receive the highest dose will not be expected to receive a total effective dose equivalent in excess of 10 mrem (0.1 mSv) per year from these emissions. If a licensee subject to this requirement exceeds this dose constraint, the licensee shall report the exceedance as provided in 641—40.97(136C) and promptly take appropriate corrective action to ensure against recurrence.

**641—40.11 to 40.14** Reserved.

OCCUPATIONAL DOSE LIMITS

**641—40.15(136C) Occupational dose limits for adults.**

**40.15(1)** The licensee or registrant shall control the occupational dose to individual adults, except for planned special exposures pursuant to 40.20(136C), to the following dose limits:

*a.* An annual limit, which is the more limiting of:

- (1) The total effective dose equivalent being equal to 5 rem (0.05 Sv); or

(2) The sum of the deep dose equivalent and the committed dose equivalent to any individual organ or tissue other than the lens of the eye being equal to 50 rem (0.5 Sv).

*b.* The annual limits to the lens of the eye, to the skin of the whole body, and to the skin of the extremities which are:

(1) A lens dose equivalent of 15 rem (0.15 Sv), and

(2) A shallow dose equivalent of 50 rem (0.5 Sv) to the skin of the whole body or to the skin of any extremity.

**40.15(2)** Doses received in excess of the annual limits, including doses received during accidents, emergencies, and planned special exposures, shall be subtracted from the limits for planned special exposures that the individual may receive during the current year and during the individual's lifetime. See 40.20(5) "a" and "b."

**40.15(3)** The assigned deep dose equivalent must be for the portion of the body receiving the highest exposure. The assigned shallow-dose equivalent must be the dose averaged over the contiguous 10 square centimeters of skin receiving the highest exposure.

The deep dose equivalent, lens dose equivalent and shallow dose equivalent may be assessed from surveys or other radiation measurements for the purpose of demonstrating compliance with the occupational dose limits, if the individual monitoring device was not in the region of highest potential exposure, or the results of individual monitoring are unavailable.

**40.15(4)** Derived air concentration (DAC) and annual limit on intake (ALI) values are presented in Table I of Appendix B and may be used to determine the individual's dose and to demonstrate compliance with the occupational dose limits. See 40.86(136C).

**40.15(5)** Notwithstanding the annual dose limits, the licensee shall limit the soluble uranium intake by an individual to 10 milligrams in a week in consideration of chemical toxicity. See footnote 3 of Appendix B.

**40.15(6)** The licensee or registrant shall reduce the dose that an individual may be allowed to receive in the current year by the amount of occupational dose received while employed by any other person. See 40.19(5).

#### **641—40.16(136C) Compliance with requirements for summation of external and internal doses.**

**40.16(1)** If the licensee or registrant is required to monitor pursuant to both 40.19(1) and 40.19(2), the licensee or registrant shall demonstrate compliance with the dose limits by summing external and internal doses. If the licensee or registrant is required to monitor only pursuant to 40.19(1), or only pursuant to 40.19(2), then summation is not required to demonstrate compliance with the dose limits. The licensee or registrant may demonstrate compliance with the requirements for summation of external and internal doses pursuant to 40.16(2), 40.16(3) and 40.16(4). The dose equivalents for the lens of the eye, the skin, and the extremities are not included in the summation, but are subject to separate limits.

**40.16(2)** Intake by inhalation. If the only intake of radionuclides is by inhalation, the total effective dose equivalent limit is not exceeded if the sum of the deep dose equivalent divided by the total effective dose equivalent limit, and one of the following, does not exceed unity:

*a.* The sum of the fractions of the inhalation ALI for each radionuclide, or

*b.* The total number of derived air concentration-hours (DAC-hours) for all radionuclides divided by 2,000, or

*c.* The sum of the calculated committed effective dose equivalents to all significantly irradiated organs or tissues (T) calculated from bioassay data using appropriate biological models and expressed as a fraction of the annual limit. For purposes of this requirement, an organ or tissue is deemed to be significantly irradiated if, for that organ or tissue, the product of the weighting factors,  $w_T$ , and the committed dose equivalent,  $H_{T,50}$ , per unit intake is greater than 10 percent of the maximum weighted value of  $H_{50}$ , that is,  $w_T H_{T,50}$ , per unit intake for any organ or tissue.

**40.16(3)** Intake by oral ingestion. If the occupationally exposed individual also receives an intake of radionuclides by oral ingestion greater than 10 percent of the applicable oral ALI, the licensee shall account for this intake and include it in demonstrating compliance with the limits.

**40.16(4)** Intake through wounds or absorption through skin. The licensee shall evaluate and, to the extent practical, account for intakes through wounds or skin absorption. The intake through intact skin has been included in the calculation of DAC for hydrogen-3 and does not need to be evaluated or accounted for pursuant to this subrule.

**641—40.17(136C) Determination of external dose from airborne radioactive material.**

**40.17(1)** Licensees shall, when determining the dose from airborne radioactive material, include the contribution to the deep dose equivalent, lens dose equivalent, and shallow dose equivalent from external exposure to the radioactive cloud. See Appendix B, footnotes 1 and 2.

**40.17(2)** Airborne radioactivity measurements and DAC values shall not be used as the primary means to assess the deep dose equivalent when the airborne radioactive material includes radionuclides other than noble gases or if the cloud of airborne radioactive material is not relatively uniform. The determination of the deep dose equivalent to an individual shall be based upon measurements using instruments or individual monitoring devices.

**641—40.18(136C) Determination of internal exposure.**

**40.18(1)** For purposes of assessing dose used to determine compliance with occupational dose equivalent limits, the licensee shall, when required pursuant to 40.37(136C), take suitable and timely measurements of:

- a. Concentrations of radioactive materials in air in work areas; or
- b. Quantities of radionuclides in the body; or
- c. Quantities of radionuclides excreted from the body; or
- d. Combinations of these measurements.

**40.18(2)** Unless respiratory protective equipment is used, as provided in 40.50(136C), or the assessment of intake is based on bioassays, the licensee shall assume that an individual inhales radioactive material at the airborne concentration in which the individual is present.

**40.18(3)** When specific information on the physical and biochemical properties of the radionuclides taken into the body or the behavior of the material in an individual is known, the licensee may:

- a. Use that information to calculate the committed effective dose equivalent, and, if used, the licensee shall document that information in the individual's record; and
- b. Upon prior approval of the agency, adjust the DAC or ALI values to reflect the actual physical and chemical characteristics of airborne radioactive material, for example, aerosol size distribution or density; and
- c. Separately assess the contribution of fractional intakes of Class D, W, or Y compounds of a given radionuclide to the committed effective dose equivalent. See Appendix B.

**40.18(4)** If the licensee chooses to assess intakes of Class Y material using the measurements given in 40.8(1) "b" or 40.8(1) "c," the licensee may delay the recording and reporting of the assessments for periods up to seven months, unless otherwise required by 40.96(136C) or 40.97(136C). This delay permits the licensee to make additional measurements basic to the assessments.

**40.18(5)** If the identity and concentration of each radionuclide in a mixture are known, the fraction of the DAC applicable to the mixture for use in calculating DAC-hours shall be either:

- a. The sum of the ratios of the concentration to the appropriate DAC value, that is, D, W, or Y, from Appendix B for each radionuclide in the mixture; or
- b. The ratio of the total concentration for all radionuclides in the mixture to the most restrictive DAC value for any radionuclide in the mixture.

**40.18(6)** If the identity of each radionuclide in a mixture is known, but the concentration of one or more of the radionuclides in the mixture is not known, the DAC for the mixture shall be the most restrictive DAC of any radionuclide in the mixture.

**40.18(7)** When a mixture of radionuclides in air exists, a licensee may disregard certain radionuclides in the mixture if:

- a. The licensee uses the total activity of the mixture in demonstrating compliance with the dose limits in 40.15(136C) and in complying with the monitoring requirements in 40.37(136C), and

- b.* The concentration of any radionuclide disregarded is less than 10 percent of its DAC, and
- c.* The sum of these percentages for all of the radionuclides disregarded in the mixture does not exceed 30 percent.

**40.18(8)** When determining the committed effective dose equivalent, the following information may be considered:

*a.* In order to calculate the committed effective dose equivalent, the licensee or registrant may assume that the inhalation of one ALI, or an exposure of 2,000 DAC-hours, results in a committed effective dose equivalent of 5 rem (0.05 Sv) for radionuclides that have their ALIs or DACs based on the committed effective dose equivalent.

*b.* For an ALI and the associated DAC determined by the nonstochastic organ dose limit of 50 rem (0.5 Sv), the intake of radionuclides that would result in a committed effective dose equivalent of 5 rem (0.05 Sv), that is, the stochastic ALI, is listed in parentheses in Table I of Appendix B. The licensee or registrant may, as a simplifying assumption, use the stochastic ALI to determine committed effective dose equivalent. However, if the licensee or registrant uses the stochastic ALI, the licensee or registrant shall also demonstrate that the limit in 40.15(1) "a"(2) is met.

**641—40.19(136C) Determination of prior occupational dose.**

**40.19(1)** For each individual who is likely to receive, in a year, an occupational dose requiring monitoring pursuant to this rule, the licensee or registrant shall:

- a.* Determine the occupational radiation dose received during the current year; and
- b.* Attempt to obtain the records of lifetime cumulative occupational radiation dose.

**40.19(2)** Prior to permitting an individual to participate in a planned special exposure, the licensee or registrant shall determine:

- a.* The internal and external doses from all previous planned special exposures; and
- b.* All doses in excess of the limits, including doses received during accidents and emergencies, received during the lifetime of the individual; and
- c.* All lifetime cumulative occupational radiation dose.

**40.19(3)** In complying with the requirements of 40.19(1), a licensee or registrant may:

*a.* Accept, as a record of the occupational dose that the individual received during the current year, a written signed statement from the individual, or from the individual's most recent employer for work involving radiation exposure, that discloses the nature and the amount of any occupational dose that the individual received during the current year; and

*b.* Accept, as the record of lifetime cumulative radiation dose, a form signed by the individual and countersigned by an appropriate official of the most recent employer for work involving radiation exposure, or the individual's current employer, if the individual is not employed by the licensee or registrant; and

*c.* Obtain reports of the individual's dose equivalent from the most recent employer for work involving radiation exposure, or the individual's current employer, if the individual is not employed by the licensee or registrant, by telephone, telegram, facsimile, or letter. The licensee or registrant shall request a written verification of the dose data if the authenticity of the transmitted report cannot be established.

**40.19(4)** *a.* The licensee or registrant shall record the exposure history, as required by 40.37(136C). The form or record shall show each period in which the individual received occupational exposure to radiation or radioactive material and shall be signed by the individual who received the exposure. For each period for which the licensee or registrant obtains reports, the licensee or registrant shall use the dose shown in the report in preparing the exposure history. For any period in which the licensee or registrant does not obtain a report, the licensee or registrant shall place a notation on the report indicating the periods of time for which data are not available.

*b.* Licensees or registrants are not required to reevaluate the separate external dose equivalents and internal committed dose equivalents or intakes of radionuclides assessed pursuant to the rules in this chapter in effect on or before January 1, 1994. Further, occupational exposure histories obtained and

recorded on or before January 1, 1994, would not have included effective dose equivalent, but may be used in the absence of specific information on the intake of radionuclides by the individual.

**40.19(5)** If the licensee or registrant is unable to obtain a complete record of an individual's current and previously accumulated occupational dose, the licensee or registrant shall assume:

*a.* In establishing administrative controls pursuant to 40.15(6) for the current year, that the allowable dose limit for the individual is reduced by 1.25 rem (12.5 mSv) for each quarter for which records were unavailable and the individual was engaged in activities that could have resulted in occupational radiation exposure; and

*b.* That the individual is not available for planned special exposures.

**40.19(6)** The licensee or registrant shall retain the records in 641—40.19(136C) until the agency terminates each pertinent license or registration requiring this record. The licensee or registrant shall retain records used in preparing any record for this subrule for three years after the record is made.

**641—40.20(136C) Planned special exposures.** A licensee or registrant may authorize an adult worker to receive doses in addition to and accounted for separately from the doses received under the limits specified in 40.15(136C) provided that each of the following conditions is satisfied:

**40.20(1)** The licensee or registrant authorizes a planned special exposure only in an exceptional situation when alternatives that might avoid the dose estimated to result from the planned special exposure are unavailable or impractical.

**40.20(2)** The licensee or registrant, and employer if the employer is not the licensee or registrant, specifically authorizes the planned special exposure, in writing, before the exposure occurs.

**40.20(3)** Before a planned special exposure, the licensee or registrant ensures that each individual involved is:

*a.* Informed of the purpose of the planned operation; and

*b.* Informed of the estimated doses and associated potential risks and specific radiation levels or other conditions that might be involved in performing the task; and

*c.* Instructed in the measures to be taken to keep the dose ALARA considering other risks that may be present.

**40.20(4)** Prior to permitting an individual to participate in a planned special exposure, the licensee or registrant ascertains prior doses as required by 40.19(2) during the lifetime of the individual for each individual involved.

**40.20(5)** Subject to 40.15(2), the licensee or registrant shall not authorize a planned special exposure that would cause an individual to receive a dose from all planned special exposures and all doses in excess of the limits to exceed:

*a.* The numerical values of any of the dose limits in 40.15(1) in any year; and

*b.* Five times the annual dose limits in 40.15(1) during the individual's lifetime.

**40.20(6)** The licensee or registrant maintains records of the conduct of a planned special exposure in accordance with 40.85(136C) and submits a written report in accordance with 40.98(136C).

**40.20(7)** The licensee or registrant records the best estimate of the dose resulting from the planned special exposure in the individual's record and informs the individual, in writing, of the dose within 30 days from the date of the planned special exposure. The dose from planned special exposures shall not be considered in controlling future occupational dose of the individual pursuant to 40.15(1) but shall be included in evaluations required by 40.20(1) and 40.20(2).

**641—40.21(136C) Occupational dose limits for minors.** The annual occupational dose limits for minors are 10 percent of the annual dose limits specified for adult workers in 40.15(136C).

**641—40.22(136C) Dose equivalent to an embryo/fetus.**

**40.22(1)** The licensee or registrant shall ensure that the dose equivalent to an embryo/fetus during the entire pregnancy, due to occupational exposure of a declared pregnant woman, does not exceed 0.5 rem (5 mSv). See 40.86(136C) for record-keeping requirements.

**40.22(2)** The licensee or registrant shall make efforts to avoid substantial variation<sup>1</sup> above a uniform monthly exposure rate to a declared pregnant woman so as to satisfy the limit in 40.22(1).

**40.22(3)** The dose equivalent to an embryo/fetus shall be taken as the sum of:

- a. The deep dose equivalent to the declared pregnant woman; and
- b. The dose equivalent to the embryo/fetus from radionuclides in the embryo/fetus and radionuclides in the declared pregnant woman.

**40.22(4)** If by the time the woman declares pregnancy to the licensee or registrant, the dose equivalent to the embryo/fetus has exceeded 0.5 rem (5 mSv), or is within 0.05 rem (0.5 mSv) of this dose, the licensee or registrant shall be deemed to be in compliance with 40.22(1) if the additional dose equivalent to the embryo/fetus does not exceed 0.05 rem (0.5 mSv) during the remainder of the pregnancy.

<sup>1</sup> The National Council on Radiation Protection and Measurements recommended in NCRP Report No. 91 "Recommendations on Limits for Exposure to Ionizing Radiation" (June 1, 1987) that no more than 0.05 rem (0.5 mSv) to the embryo/fetus be received in any one month.

**641—40.23 to 40.25** Reserved.

#### RADIATION DOSE LIMITS FOR INDIVIDUAL MEMBERS OF THE PUBLIC

**641—40.26(136C) Dose limits for individual members of the public.**

**40.26(1)** Each licensee or registrant shall conduct operations so that:

- a. The total effective dose equivalent to individual members of the public from the licensed or registered operation does not exceed 0.1 rem (1 millisievert) in a year, exclusive of the dose contributions from background radiation, from any medical administration the individual has received, from exposure to individuals administered radioactive material and released in accordance with 641—subrule 41.2(27), from voluntary participation in medical research programs, and from the licensee's or registrant's disposal of radioactive material into sanitary sewerage under 641—40.72(136C); and
- b. The dose in any unrestricted area from external sources, exclusive of the dose contributions from patients administered radioactive material and released under 641—subrule 41.2(27), does not exceed 0.002 rem (0.02 millisievert) in any one hour.

**40.26(2)** If the licensee or registrant permits members of the public to have access to controlled areas, the limits for members of the public continue to apply to those individuals.

**40.26(3)** A licensee, registrant, or an applicant for a license or registration may apply for prior agency authorization to operate up to an annual dose limit for an individual member of the public of 0.5 rem (5 mSv). This application shall include the following information:

- a. Demonstration of the need for and the expected duration of operations in excess of the limit in 40.26(1); and
- b. The licensee's or registrant's program to assess and control dose within the 0.5 rem (5 mSv) annual limit; and
- c. The procedures to be followed to maintain the dose ALARA.

**40.26(4)** In addition to the requirements of this chapter, a licensee or registrant subject to the provisions of the U.S. Environmental Protection Agency's generally applicable environmental radiation standards in 40 CFR 190 shall comply with those standards.

**40.26(5)** The agency may impose additional restrictions on radiation levels in unrestricted areas and on the total quantity of radionuclides that a licensee or registrant may release in effluents in order to restrict the collective dose.

**40.26(6)** Notwithstanding the requirements of 40.26(1) "a," a licensee may permit visitors to an individual who cannot be released under 641—subrule 41.2(27) to receive a radiation dose greater than 0.1 rem (1 mSv) if:

- a. The radiation dose received does not exceed 0.5 rem (5 mSv); and
- b. The authorized user, as defined in 641—subrule 41.2(2), has determined before the visit that it is appropriate.



**641—40.27(136C) Compliance with dose limits for individual members of the public.**

**40.27(1)** The licensee or registrant shall make or cause to be made, as appropriate, surveys of radiation levels in unrestricted and controlled areas and radioactive materials in effluents released to unrestricted and controlled areas to demonstrate compliance with the dose limits for individual members of the public in 40.26(136C).

**40.27(2)** A licensee or registrant shall show compliance with the annual dose limit in 40.26(136C) by:

*a.* Demonstrating by measurement or calculation that the total effective dose equivalent to the individual likely to receive the highest dose from the licensed or registered operation does not exceed the annual dose limit; or

*b.* Demonstrating that:

(1) The annual average concentrations of radioactive material released in gaseous and liquid effluents at the boundary of the unrestricted area do not exceed the values specified in Table II of Appendix B; and

(2) If an individual were continually present in an unrestricted area, the dose from external sources would not exceed 0.002 rem (0.02 mSv) in an hour and 0.05 rem (0.5 mSv) in a year.

**40.27(3)** Upon approval from the agency, the licensee or registrant may adjust the effluent concentration values in Appendix B, Table II, for members of the public, to take into account the actual physical and chemical characteristics of the effluents, such as aerosol size distribution, solubility, density, radioactive decay equilibrium, and chemical form.

## RADIOLOGICAL CRITERIA FOR LICENSE TERMINATION

**641—40.28(136C) Radiological criteria for license termination.**

**40.28(1)** The criteria in this rule apply to the decommissioning of facilities licensed under 641—Chapter 39, and to the release of part of a facility or site for unrestricted use, as well as other facilities subject to the agency's jurisdiction under Iowa Code chapter 136C.

**40.28(2)** The criteria in this rule do not apply to sites which:

*a.* Have been decommissioned prior to July 1, 1999, in accordance with criteria identified in 641—subrule 39.4(33).

*b.* Have previously submitted and received agency approval on a license termination plan (LTP) or decommissioning plan that is compatible with the United States Nuclear Regulatory Commission (NRC) Site Decommissioning Management Plan (SDMP) Action Plan criteria; or

*c.* Submit a sufficient LTP or decommissioning plan prior to July 1, 1999, and such LTP or decommissioning plan is approved by the agency prior to July 1, 1999, except that if an environmental impact statement is required in the submittal, there will be a provision for day-to-day extension.

**40.28(3)** After a site has been decommissioned and the license terminated in accordance with the criteria in this chapter, or after part of a facility or site has been released for unrestricted use in accordance with this chapter, the agency will require additional cleanup only if, based on new information, it determines that the criteria of this chapter were not met and residual radioactivity remaining at the site could result in significant threat to public health and safety.

**40.28(4)** When calculating TEDE to the average member of the critical group the licensee shall determine the peak annual TEDE dose expected within the first 1000 years after decommissioning.

**40.28(5)** Public notification and public participation. Upon the receipt of an LTP or decommissioning plan from the licensee or a proposal by the licensee for release of a site pursuant to 40.30(136C) or 40.31(136C) or whenever the agency deems such notice to be in the public interest, the agency shall:

*a.* Notify and solicit comments from:

(1) Local and state governments in the vicinity of the site and any Indian nation or other indigenous people that have treaty or statutory rights that could be affected by the decommissioning; and

(2) The Environmental Protection Agency for cases where the licensee proposes to release a site pursuant to 40.31(136C).

*b.* Publish a notice in the Iowa Administrative Bulletin and in a forum, such as local newspapers, letters to state or local organizations, or other appropriate forum, that is readily accessible to individuals in the vicinity of the site, and solicit comments from affected parties.

**40.28(6)** Minimization of contamination. Applicants for licenses, other than renewals, after July 1, 1999, shall describe in the application how facility design and procedures for operation will minimize, to the extent practicable, contamination of the facility and the environment, facilitate eventual decommissioning, and minimize, to the extent practicable, the generation of radioactive waste.

**641—40.29(136C) Radiological criteria for unrestricted use.** A site will be considered acceptable for unrestricted use if the residual radioactivity that is distinguishable from background radiation results in a TEDE to an average member of the critical group that does not exceed 25 mrem (0.25 mSv) per year, including that from groundwater sources of drinking water, and the residual radioactivity has been reduced to levels that are ALARA. Determination of the levels which are ALARA must take into account consideration of any detriments, such as deaths from transportation accidents, expected to potentially result from decontamination and waste disposal.

**641—40.30(136C) Criteria for license termination under restricted conditions.** A site will be considered acceptable for license termination under restricted conditions if:

**40.30(1)** The licensee can demonstrate that reductions in residual radioactivity necessary to comply with the provisions of 40.29(136C) would result in net public or environmental harm or were not being made because the residual levels associated with restricted conditions are ALARA. Determination of the levels which are ALARA must take into account consideration of any detriments, such as traffic accidents, expected to potentially result from decontamination and waste disposal;

**40.30(2)** The licensee has made provisions for legally enforceable institutional controls that provide reasonable assurance that the TEDE from residual radioactivity distinguishable from background to the average member of the critical group will not exceed 25 mrem (0.25 mSv) per year;

**40.30(3)** The licensee has provided sufficient financial assurance to enable an independent third party, including a governmental custodian of a site, to assume and carry out responsibilities for any necessary control and maintenance of the site. Acceptable financial assurance mechanisms are:

*a.* Funds placed into an account segregated from the licensee's assets and outside the licensee's administrative control as described in 641—subparagraph 39.4(26) "f"(1);

*b.* Surety method, insurance or other guarantee method as described in 641—subparagraph 39.4(26) "f"(2);

*c.* A statement of intent in the case of federal, state, or local government licensees, as described in 641—subparagraph 39.4(26) "f"(4); or

*d.* When a governmental entity is assuming custody and ownership of a site, an arrangement that is deemed acceptable by such governmental entity.

**40.30(4)** The licensee has submitted a decommissioning plan or license termination plan (LTP) to the agency indicating the licensee's intent to decommission in accordance with 641—paragraph 39.4(33) "d" and specifying that the licensee intends to decommission by restricting use of the site. The licensee shall document in the LTP or decommissioning plan how the advice of individuals and institutions in the community, who may be affected by the decommissioning, has been sought and incorporated, as appropriate, following analysis of that advice. Licensees proposing to decommission by restricting use of the site shall seek advice from such affected parties regarding the following matters concerning the proposed decommissioning:

*a.* Whether provisions for institutional controls proposed by the licensee:

(1) Will provide reasonable assurance that the TEDE from residual radioactivity distinguishable from background to the average member of the critical group will not exceed 25 mrem (0.25 mSv) per year;

(2) Will be enforceable; and

- (3) Will not impose undue burdens on the local community or other affected parties.
- b. Whether the licensee has provided sufficient financial assurance to enable an independent third party, including a governmental custodian of a site, to assume and carry out responsibilities for any necessary control and maintenance of the site;
- c. In seeking advice on the issues identified in 40.30(4) "a," the licensee shall provide for:
  - (1) Participation by representatives of a broad cross section of community interests who may be affected by the decommissioning;
  - (2) An opportunity for a comprehensive, collective discussion of the issues by the participants represented; and
  - (3) A publicly available summary of the results of all such discussions, including a description of the individual viewpoints of the participants on the issues and the extent of agreement and disagreement among the participants on the issues; and

**40.30(5)** Residual radioactivity at the site has been reduced so that if the institutional controls were no longer in effect, there is reasonable assurance that the TEDE from residual radioactivity distinguishable from background to the average member of the critical group is as low as reasonably achievable and would not exceed either:

- a. 100 mrem (1 mSv) per year; or
- b. 500 mrem (5 mSv) per year provided the licensee:
  - (1) Demonstrates that further reductions in residual radioactivity necessary to comply with the 100 mrem/yr (1 mSv/yr) value of 40.30(5) "a" are not technically achievable, would be prohibitively expensive, or would result in net public or environmental harm;
  - (2) Makes provisions for durable institutional controls; and
  - (3) Provides sufficient financial assurance to enable a responsible government entity or independent third party, including a governmental custodian of a site, both to carry out periodic rechecks of the site no less frequently than every five years to ensure that the institutional controls remain in place as necessary to meet the criteria of 40.30(2) and to assume and carry out responsibilities for any necessary controls and maintenance of those controls. Acceptable financial assurance mechanisms are those in subrule 40.30(3).

**641—40.31(136C) Alternate criteria for license termination.**

**40.31(1)** The agency may terminate a license using alternate criteria greater than the dose criterion of 641—40.29(136C), 40.30(2) and 40.30(4) "a"(1) if the licensee:

- a. Provides assurance that public health and safety would continue to be protected and that it is unlikely that the dose from all man-made sources combined, other than medical, would be more than the 100 mrem/yr (1 mSv/yr) by submitting an analysis of possible sources of exposure;
- b. Has employed, to the extent practical, restrictions on site use according to the provisions of 641—40.30(136C) in minimizing exposures at the site;
- c. Reduces doses to ALARA levels taking into consideration any detriments such as traffic accidents expected to potentially result from decontamination and waste disposal; and
- d. Has submitted a decommissioning plan or license termination plan (LTP) to the agency indicating the licensee's intent to decommission in accordance with 641—paragraph 39.4(33) "d," and specifying that the licensee proposes to decommission by use of alternate criteria. The licensee shall document in the decommissioning plan or LTP how the advice of individuals and institutions in the community, who may be affected by the decommissioning, has been sought and addressed, as appropriate, following analysis of that advice. In seeking such advice, the licensee shall provide for:
  - (1) Participation by representatives of a broad cross section of community interests who may be affected by the decommissioning;
  - (2) An opportunity for a comprehensive, collective discussion on the issues by the participants represented; and
  - (3) A publicly available summary of the results of all such discussions, including a description of the individual viewpoints of the participants on the issues and the extent of agreement and disagreement among the participants on the issues.

**40.31(2)** The use of alternate criteria to terminate a license requires the approval of the agency after consideration of the staff's recommendations that will address any comments provided by the Environmental Protection Agency and any public comments submitted pursuant to 40.32(136C).

TESTING FOR LEAKAGE OR CONTAMINATION OF SEALED SOURCES

**641—40.32(136C) Testing for leakage or contamination of sealed sources.**

**40.32(1)** The licensee in possession of any sealed source shall ensure that:

*a.* Each sealed source, except as specified in 40.32(2), is tested for leakage or contamination and the test results are received before the sealed source is put into use unless the licensee has a certificate from the transferor indicating that the sealed source was tested within six months before transfer to the licensee.

*b.* Each sealed source that is not designed to emit alpha particles is tested for leakage or contamination at intervals not to exceed six months or at alternative intervals approved by the Agency, after evaluation of information specified by 641—subparagraphs 39.4(29)“l”(4) and 39.4(29)“l”(5) of these rules, an Agreement State, a Licensing State, or the U.S. Nuclear Regulatory Commission.

*c.* Each sealed source that is designed to emit alpha particles is tested for leakage or contamination at intervals not to exceed three months or at alternative intervals approved by the Agency, after evaluation of information specified by 641—subparagraphs 39.4(29)“l”(4) and 39.4(29)“l”(5) of these rules, an Agreement State, a Licensing State, or the Nuclear Regulatory Commission.

*d.* For each sealed source that is required to be tested for leakage or contamination, at any other time there is reason to suspect that the sealed source might have been damaged or might be leaking, the licensee or registrant shall ensure that the sealed source is tested for leakage or contamination before further use.

*e.* Tests for leakage for all sealed sources, except brachytherapy sources manufactured to contain radium, shall be capable of detecting the presence of 0.005  $\mu\text{Ci}$  (185 Bq) of radioactive material on a test sample. Test samples shall be taken from the sealed source or from the surfaces of the container in which the sealed source is stored or mounted on which one might expect contamination to accumulate. For a sealed source contained in a device, test samples are obtained when the source is in the “off” position.

*f.* The test for leakage for brachytherapy sources manufactured to contain radium shall be capable of detecting an absolute leakage rate of 0.001  $\mu\text{Ci}$  (37 Bq) of radon-222 in a 24-hour period when the collection efficiency for radon-222 and its daughters has been determined with respect to collection method, volume and time.

*g.* Tests for contamination from radium daughters shall be taken on the interior surface of brachytherapy source storage containers and shall be capable of detecting the presence of 0.005  $\mu\text{Ci}$  (185 Bq) of a radium daughter which has a half-life greater than four days.

**40.32(2)** A licensee need not perform tests for leakage or contamination on the following sealed sources:

- a.* Sealed sources containing only radioactive material with a half-life of less than 30 days;
- b.* Sealed sources containing only radioactive material as a gas;
- c.* Sealed sources containing 100  $\mu\text{Ci}$  (3.7 MBq) or less of beta- or photon-emitting material or 10  $\mu\text{Ci}$  (370 kBq) or less of alpha-emitting material;
- d.* Sealed sources containing only hydrogen-3;
- e.* Seeds of iridium-192 encased in nylon ribbon; and
- f.* Sealed sources, except those used in teletherapy and brachytherapy and those containing radium, which are stored, not being used and identified as in storage. The licensee shall, however, test each such sealed source for leakage or contamination and receive the test results before any use or transfer unless it has been tested for leakage or contamination within six months before the date of use or transfer.

**40.32(3)** Tests for leakage or contamination from sealed sources shall be performed by persons specifically authorized by the agency, an Agreement State, a Licensing State, or the U.S. Nuclear Regulatory Commission to perform such services.

**40.32(4)** Test results shall be kept in units of microcurie or becquerel and maintained for inspection by the agency.

**40.32(5)** The following shall be considered evidence that a sealed source is leaking:

- a. The presence of 0.005  $\mu\text{Ci}$  (185 Bq) or more of removable contamination on any test sample.
- b. Leakage of 0.001  $\mu\text{Ci}$  (37 Bq) of radon-222 per 24 hours for brachytherapy sources manufactured to contain radium.
- c. The presence of removable contamination resulting from the decay of 0.005  $\mu\text{Ci}$  (185 Bq) or more of radium.

**40.32(6)** The licensee shall immediately withdraw a leaking sealed source from use and shall take action to prevent the spread of contamination. The leaking sealed source shall be repaired or disposed of in accordance with this chapter.

**40.32(7)** Reports of test results for leaking or contaminated sealed sources shall be made pursuant to 40.102(136C).

**641—40.33 to 40.35** Reserved.

#### SURVEYS AND MONITORING

**641—40.36(136C) Surveys and monitoring—general.**

**40.36(1)** Each licensee or registrant shall make, or cause to be made, surveys that:

- a. Are necessary for the licensee or registrant to comply with this chapter; and
- b. Are necessary under the circumstances to evaluate:
  - (1) The magnitude and extent of radiation levels; and
  - (2) Concentrations or quantities of radioactive material; and
  - (3) The potential radiological hazards that could be present.

**40.36(2)** The licensee or registrant shall ensure that instruments and equipment used for quantitative radiation measurements, for example, dose rate and effluent monitoring, are calibrated at intervals not to exceed 12 months for the radiation measured except when a more frequent interval is specified in another applicable part of these rules or a license condition.

**40.36(3)** All personnel dosimeters, except for direct and indirect reading pocket ionization chambers and those dosimeters used to measure the dose to any extremity, that require processing to determine the radiation dose and that are used by licensees and registrants to comply with 40.15(136C), with other applicable provisions of these rules, or with conditions specified in a license or registration shall be processed and evaluated by a dosimetry processor:

- a. Holding current personnel dosimetry accreditation from the National Voluntary Laboratory Accreditation Program (NVLAP) of the National Institute of Standards and Technology; and
- b. Approved in this accreditation process for the type of radiation or radiations included in the NVLAP program that most closely approximates the type of radiation or radiations for which the individual wearing the dosimeter is monitored.

**40.36(4)** The licensee or registrant shall ensure that adequate precautions are taken to prevent a deceptive exposure of an individual monitoring device.

**40.36(5)** After replacement, each personnel dosimeter must be sent for processing as soon as possible.

**641—40.37(136C) Conditions requiring individual monitoring of external and internal occupational dose.** Each licensee or registrant shall monitor exposures from sources of radiation at levels sufficient to demonstrate compliance with the occupational dose limits of this chapter. As a minimum:

**40.37(1)** Each licensee or registrant shall monitor occupational exposure to radiation and shall supply and require the use of individual monitoring devices by:

- a. Adults likely to receive, in 1 year from sources external to the body, a dose in excess of 10 percent of the limits in 40.15(1);

*b.* Minors likely to receive, in 1 year from sources external to the body, a deep dose equivalent in excess of 0.15 rem (1.5 mSv), or a shallow dose equivalent to the skin or to the extremities in excess of 0.5 rem (1 mSv);

*c.* Individuals entering a high or very high radiation area;

*d.* Individuals working with medical fluoroscopic equipment; and

*e.* Declared pregnant women likely to receive during the entire pregnancy, from radiation sources external to the body, a deep dose equivalent in excess of 0.1 rem (1 mSv).

**40.37(2)** Each licensee or registrant shall monitor, to determine compliance with 40.18(136C), the occupational intake of radioactive material by and assess the committed effective dose equivalent to:

*a.* Adults likely to receive, in 1 year, an intake in excess of 10 percent of the applicable ALI in Table I, Columns 1 and 2, of Appendix B;

*b.* Minors likely to receive, in 1 year, a committed effective dose equivalent in excess of 0.1 rem (1 mSv); and

*c.* Declared pregnant women likely to receive, during the entire pregnancy, a committed effective dose equivalent in excess of 0.1 rem (1 mSv).

**40.37(3)** Location of individual monitoring devices. Each licensee or registrant shall ensure that individuals who are required to monitor occupational doses in accordance with 40.37(136C) wear individual monitoring devices as follows:

*a.* An individual monitoring device used for monitoring the dose to the whole body shall be worn at the unshielded portion of the whole body likely to receive the highest exposure. When a protective apron is worn, the location of the individual monitoring device shall be near the midline of the body, under the apron;

*b.* An individual monitoring device used for monitoring the dose to an embryo/fetus of a declared pregnant woman shall be located at the waist under any protective apron being worn by the woman;

*c.* An individual monitoring device used for monitoring the eye dose equivalent, to demonstrate compliance with 40.15(136C) shall be located at the neck (collar), outside any protective apron being worn by the monitored individual, or at an unshielded location closer to the eye;

*d.* An individual monitoring device used for monitoring the dose to the extremities, to demonstrate compliance with 40.15(136C), shall be worn on the extremity likely to receive the highest exposure. Each individual monitoring device shall be oriented to measure the highest dose to the extremity being monitored.

**641—40.38 to 40.41** Reserved.

#### CONTROL OF EXPOSURE FROM EXTERNAL SOURCES IN RESTRICTED AREAS

**641—40.42(136C) Control of access to high radiation areas.**

**40.42(1)** The licensee or registrant shall ensure that each entrance or access point to a high radiation area has one or more of the following features:

*a.* A control device that, upon entry into the area, causes the level of radiation to be reduced below that level at which an individual might receive a deep dose equivalent of 0.1 rem (1 mSv) in 1 hour at 30 centimeters from the source of radiation from any surface that the radiation penetrates; or

*b.* 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; or

*c.* Entryways that are locked, except during periods when access to the areas is required, with positive control over each individual entry.

**40.42(2)** In place of the controls required by 40.42(1) for a high radiation area, the licensee or registrant may substitute continuous direct or electronic surveillance that is capable of preventing unauthorized entry.

**40.42(3)** The licensee or registrant may apply to the Agency for approval of alternative methods for controlling access to high radiation areas.

**40.42(4)** The licensee or registrant shall establish the controls required by 40.42(1) and 40.42(3) in a way that does not prevent individuals from leaving a high radiation area.

**40.42(5)** The licensee is not required to control each entrance or access point to a room or other area that is a high radiation area solely because of the presence of radioactive materials prepared for transport and packaged and labeled in accordance with the rules of the U.S. Department of Transportation provided that:

- a. The packages do not remain in the area longer than three days; and
- b. The dose rate at 1 meter from the external surface of any package does not exceed 0.01 rem (0.1 mSv) per hour.

**40.42(6)** The licensee is not required to control entrance or access to rooms or other areas in hospitals solely because of the presence of patients containing radioactive material, provided that there are personnel in attendance who are taking the necessary precautions to prevent the exposure of individuals to radiation or radioactive material in excess of the established limits in this chapter and to operate within the ALARA provisions of the licensee's radiation protection program.

**40.42(7)** The licensee or registrant is not required to control entrance or access to rooms or other areas containing sources of radiation capable of producing a high radiation area as described in 641—40.42(136C) if the registrant has met all the specific requirements for access and control specified in other applicable chapters such as 641—Chapter 45 for industrial radiography, 641—Chapter 41 for X-rays in the healing arts, and 641—Chapter 41 for particle accelerators.

**641—40.43(136C) Control of access to very high radiation areas.**

**40.43(1)** In addition to the requirements in 40.42(136C), the licensee or registrant shall institute measures to ensure that an individual is not able to gain unauthorized or inadvertent access to areas in which radiation levels could be encountered at 500 rad (5 Gy) or more in 1 hour at 1 meter from a source of radiation or any surface through which the radiation penetrates. This requirement does not apply to rooms or areas in which diagnostic X-ray systems are the only source of radiation, or to non-self-shielded irradiators.

**40.43(2)** The registrant is not required to control entrance or access to rooms or other areas containing sources of radiation capable of producing a very high radiation area as described in 40.43(1) if the registrant has met all the specific requirements for access and control specified in other applicable chapters such as 641—Chapter 45 for industrial radiography, 641—Chapter 41 for X-rays in the healing arts, and 641—Chapter 41 for particle accelerators.

**641—40.44(136C) Control of access to very high radiation areas—irradiators.**

**40.44(1)** This rule applies to licensees with sources of radiation in non-self-shielded irradiators. This rule does not apply to sources of radiation that are used in teletherapy, in industrial radiography, or in completely self-shielded irradiators in which the source of radiation is both stored and operated within the same shielding radiation barrier and, in the designed configuration of the irradiator, is always physically inaccessible to any individual and cannot create high levels of radiation in an area that is accessible to any individual.

**40.44(2)** Each area in which there may exist radiation levels in excess of 500 rad (5 Gy) in 1 hour at 1 meter from a source of radiation that is used to irradiate materials shall meet the following requirements:

- a. Each entrance or access point shall be equipped with entry control devices which:
  - (1) Function automatically to prevent any individual from inadvertently entering a very high radiation area; and
  - (2) Permit deliberate entry into the area only after a control device is actuated that causes the radiation level within the area, from the source of radiation, to be reduced below that at which it would be possible for an individual to receive a deep dose equivalent in excess of 0.1 rem (1 mSv) in 1 hour; and
  - (3) Prevent operation of the source of radiation if it would produce radiation levels in the area that could result in a deep dose equivalent to an individual in excess of 0.1 rem (1 mSv) in 1 hour.

*b.* Additional control devices shall be provided so that, upon failure of the entry control devices to function as required by 40.44(2) "a":

(1) The radiation level within the area, from the source of radiation, is reduced below that at which it would be possible for an individual to receive a deep dose equivalent in excess of 0.1 rem (1 mSv) in 1 hour; and

(2) Conspicuous visible and audible alarm signals are generated to make an individual attempting to enter the area aware of the hazard and at least one other authorized individual, who is physically present, familiar with the activity, and prepared to render or summon assistance, aware of the failure of the entry control devices.

*c.* The licensee shall provide control devices so that, upon failure or removal of physical radiation barriers other than the sealed source's shielded storage container:

(1) The radiation level from the source of radiation is reduced below that at which it would be possible for an individual to receive a deep dose equivalent in excess of 0.1 rem (1 mSv) in 1 hour; and

(2) Conspicuous visible and audible alarm signals are generated to make potentially affected individuals aware of the hazard and the licensee or at least one other individual, who is familiar with the activity and prepared to render or summon assistance, aware of the failure or removal of the physical barrier.

*d.* When the shield for stored sealed sources is a liquid, the licensee shall provide means to monitor the integrity of the shield and to signal, automatically, loss of adequate shielding.

*e.* Physical radiation barriers that comprise permanent structural components, such as walls, that have no credible probability of failure or removal in ordinary circumstances need not meet the requirements of 40.44(2) "c" and 40.44(2) "d."

*f.* Each area shall be equipped with devices that will automatically generate conspicuous visible and audible alarm signals to alert personnel in the area before the source of radiation can be put into operation and in time for any individual in the area to operate a clearly identified control device, which must be installed in the area and which can prevent the source of radiation from being put into operation.

*g.* Each area shall be controlled by use of such administrative procedures and such devices as are necessary to ensure that the area is cleared of personnel prior to each use of the source of radiation.

*h.* Each area shall be checked by a radiation measurement to ensure that, prior to the first individual's entry into the area after any use of the source of radiation, the radiation level from the source of radiation in the area is below that at which it would be possible for an individual to receive a deep dose equivalent in excess of 0.1 rem (1 mSv) in 1 hour.

*i.* The entry control devices required in 40.44(2) "a" shall be tested for proper functioning. See 40.89(136C) for record-keeping requirements.

(1) Testing shall be conducted prior to initial operation with the source of radiation on any day, unless operations were continued uninterrupted from the previous day; and

(2) Testing shall be conducted prior to resumption of operation of the source of radiation after any unintentional interruption; and

(3) The licensee or registrant shall submit and adhere to a schedule for periodic tests of the entry control and warning systems.

*j.* The licensee or registrant shall not conduct operations, other than those necessary to place the source of radiation in safe condition or to effect repairs on controls, unless control devices are functioning properly.

*k.* Entry and exit portals that are used in transporting materials to and from the irradiation area, and that are not intended for use by individuals, shall be controlled by such devices and administrative procedures as are necessary to physically protect and warn against inadvertent entry by any individual through these portals. Exit portals for irradiated materials shall be equipped to detect and signal the presence of any loose radioactive material that is carried toward such an exit and to automatically prevent loose radioactive material from being carried out of the area.

**40.44(3)** Licensees, registrants, or applicants for licenses or registrations for sources of radiation within the purview of 40.44(2) which will be used in a variety of positions or in locations, such as open fields or forests, that make it impracticable to comply with certain requirements of 40.44(2), such as



those for the automatic control of radiation levels, may apply to the Agency for approval of alternative safety measures. Alternative safety measures shall provide personnel protection at least equivalent to those specified in 40.44(2). At least one of the alternative measures shall include an entry-preventing interlock control based on a measurement of the radiation that ensures the absence of high radiation levels before an individual can gain access to the area where such sources of radiation are used.

**40.44(4)** The entry control devices required by 40.44(2) and 40.44(3) shall be established in such a way that no individual will be prevented from leaving the area.

**641—40.45 to 40.47** Reserved.

RESPIRATORY PROTECTION AND CONTROLS TO RESTRICT  
INTERNAL EXPOSURE IN RESTRICTED AREAS

**641—40.48(136C) Use of process or other engineering controls.** The licensee shall use, to the extent practical, process or other engineering controls, such as containment, decontamination, or ventilation, to control the concentrations of radioactive material in air.

**641—40.49(136C) Use of other controls.**

**40.49(1)** When it is not practical to apply process or other engineering controls to control the concentrations of radioactive material in air to values below those that define an airborne radioactivity area, the licensee shall, consistent with maintaining the total effective dose equivalent ALARA, increase monitoring and limit intakes by one or more of the following means:

- a. Control of access;
- b. Limitation of exposure times;
- c. Use of respiratory protection equipment; or
- d. Other controls.

**40.49(2)** If the licensee performs an ALARA analysis to determine whether or not respirators should be used, the licensee may consider safety factors other than radiological factors. The licensee should also consider the impact of respirator use on workers' industrial health and safety.

**641—40.50(136C) Use of individual respiratory protection equipment.**

**40.50(1)** If the licensee assigns or permits the use of respiratory protection equipment to limit intakes pursuant to 40.49(136C):

- a. The licensee shall use only respiratory protection equipment that is tested and certified by the National Institute for Occupational Safety and Health (NIOSH), except as otherwise noted in this subrule.
- b. If the licensee wishes to use equipment that has not been tested or certified by the National Institute for Occupational Safety and Health or for which there is no schedule for testing or certification, the licensee shall submit an application for authorized use of that equipment, including a demonstration by testing, or a demonstration on the basis of reliable test information, that the material and performance characteristics of the equipment are capable of providing the proposed degree of protection under anticipated conditions of use.

- c. The licensee or registrant shall implement and maintain a respiratory protection program that includes:

- (1) Air sampling sufficient to identify the potential hazard, permit proper equipment selection, and estimate doses;
- (2) Surveys and bioassays, as appropriate, to evaluate actual intakes;
- (3) Testing of respirators for operability (user seal check for face sealing devices and functional check for others) immediately prior to each use;
- (4) Written procedures regarding monitoring, including air sampling and bioassays; supervision and training of respirator user; fit testing; respirator selection; breathing air quality; inventory and control; storage, issuance, maintenance, repair, testing, and quality assurance of respiratory protection equipment; record keeping; and limitations on periods of respirator use and relief from respirator use;

(5) Determination by a physician that the individual user is medically fit to use respiratory protection equipment: before the initial fitting of a face-sealing respirator; before the first field use of non-face-sealing respirators; and either every 12 months thereafter, or periodically at a frequency determined by a physician; and

(6) Fit testing, with a fit factor equal to or greater than 10 times the APF for negative pressure devices, and a fit factor equal to or greater than 500 for any positive pressure, continuous flow, and pressure-demand devices, before the first field use of tight-fitting, face-sealing respirators and periodically thereafter at a frequency not to exceed one year. Fit testing must be performed with the facepiece operating in the negative pressure mode.

*d.* The licensee shall advise each respirator user that the user may leave the area at any time for relief from respirator use in the event of equipment malfunction, physical or psychological distress, procedural or communication failure, significant deterioration of operating conditions, or any other conditions that might require such relief.

*e.* The licensee shall also consider limitations appropriate to the type and mode of use. When selecting respiratory devices, the licensee shall provide for vision correction, adequate communication, low temperature work environments, and the concurrent use of other safety or radiological protection equipment. The licensee shall use equipment in such a way as not to interfere with the proper operation of the respirator.

*f.* Standby rescue persons are required whenever one-piece atmosphere-supplying suits or any combination of supplied air respiratory protection devices and personnel protection equipment is used from which an unaided individual would have difficulty extricating himself or herself. The standby rescue persons must be equipped with respiratory protection devices or other apparatus appropriate for the potential hazards. The standby rescue persons shall observe or otherwise maintain continuous communication (visual, voice, signal line, telephone, radio, or other suitable means) with the workers, and be immediately available to assist the workers in case of a failure of the air supply or for any other reason that requires relief from distress. A sufficient number of standby rescue persons must be immediately available to assist all users of this type of equipment and to provide effective emergency rescue if needed.

*g.* Atmosphere-supplying respirators must be supplied with respirable air of grade D quality or better as defined by the Compressed Gas Association in publication G-7.1, "Commodity Specification for Air," 1997, and included in the regulations of the Occupational Safety and Health Administration (29 CFR 1910.134(i)(1)(ii)(A) through (E)). Grade D quality air criteria include:

- (1) Oxygen content (v/v) of 19.5 to 23.5 percent;
- (2) Hydrocarbon (condensed) content of 5 milligrams per cubic meter of air or less;
- (3) Carbon monoxide (CO) content of 10 ppm or less;
- (4) Carbon dioxide content of 1000 ppm or less; and
- (5) Lack of noticeable odor.

*h.* The licensee shall ensure that no objects, materials or substances, such as facial hair, or any conditions that interfere with the face, facepiece seal or valve function, and that are under the control of the respirator wearer, are present between the skin of the wearer's face and the sealing surface of a tight-fitting respirator facepiece.

*i.* In the estimation of the dose to individuals from intake of airborne radioactive materials, the concentration of radioactive material in the air that is inhaled when respirators are worn is initially assumed to be the ambient concentration in air without respiratory protection, divided by the assigned protection factor. If the dose is later found to be greater than the estimated dose, the corrected value must be used. If the dose is later found to be less than the estimated dose, the corrected value may be used.

**40.50(2)** When estimating exposure of individuals to airborne radioactive materials, the licensee may make allowance for respiratory protection equipment used to limit intakes pursuant to 40.49(136C), provided that the following conditions, in addition to those in 40.50(1), are satisfied:

*a.* The licensee selects respiratory protection equipment that provides a protection factor, specified in Appendix A, greater than the multiple by which peak concentrations of airborne radioactive materials in the working area are expected to exceed the values specified in Appendix B, Table I, Column 3.

However, if the selection of respiratory protection equipment with a protection factor greater than the multiple defined in the preceding sentence is inconsistent with the goal specified in 40.49(136C) of keeping the total effective dose equivalent ALARA, the licensee or registrant may select respiratory protection equipment with a lower protection factor provided that such a selection would result in a total effective dose equivalent that is ALARA. The concentration of radioactive material in the air that is inhaled when respirators are worn may be initially estimated by dividing the average concentration in air, during each period of uninterrupted use, by the protection factor. If the exposure is later found to be greater than initially estimated, the corrected value shall be used; if the exposure is later found to be less than initially estimated, the corrected value may be used.

*b.* The licensee shall obtain authorization from the agency before assigning respiratory protection factors in excess of those specified in Appendix A. The agency may authorize a licensee to use higher protection factors on receipt of an application that:

- (1) Describes the situation for which a need exists for higher protection factors, and
- (2) Demonstrates that the respiratory protection equipment provides these higher protection factors under the proposed conditions of use.

**40.50(3)** In an emergency, the licensee shall use as emergency equipment only respiratory protection equipment that has been specifically certified or had certification extended for emergency use by the National Institute for Occupational Safety and Health and the Mine Safety and Health Administration.

**40.50(4)** Further restrictions.

*a.* The licensee shall notify the agency in writing at least 30 days before the date that respiratory protection equipment is first used pursuant to either 40.50(1) or 40.50(2).

*b.* The agency may impose restrictions in addition to those listed in these rules in order to:

- (1) Ensure that the respiratory protection program of the licensee is adequate to limit doses to individuals from intakes of airborne radioactive materials consistent with maintaining total effective dose equivalent ALARA; and
- (2) Limit the extent to which a licensee may use respiratory protection equipment instead of process or other engineering controls.

**641—40.51 to 40.53** Reserved.

STORAGE AND CONTROL OF LICENSED OR REGISTERED  
SOURCES OF RADIATION

**641—40.54(136C) Security and control of licensed radioactive material in quantities of concern.**

**40.54(1)** The following increased controls apply to licensees that, at any given time, possess radioactive sources greater than or equal to the quantities of concern of radioactive material defined in Appendix G.

**40.54(2)** In order to ensure the safe handling, use, and control of licensed material in use and in storage, each licensee shall control access at all times to radioactive material quantities of concern and devices containing such radioactive material (devices), and limit access to such radioactive material and devices to only approved individuals who require access to perform their duties.

*a.* The licensee shall allow only trustworthy and reliable individuals, approved in writing by the licensee, to have unescorted access to radioactive material quantities of concern and devices. The licensee shall approve for unescorted access only those individuals with job duties that require access to such radioactive material and devices. Personnel who require access to such radioactive material and devices to perform a job duty, but who are not approved by the licensee for unescorted access, must be escorted by an approved individual.

*b.* For individuals employed by the licensee for three years or less, and for nonlicensee personnel, such as physicians, physicists, housekeeping personnel, and security personnel under contract, trustworthiness and reliability shall be determined, at a minimum, by verifying employment history, education, and personal references. The licensee shall also, to the extent possible, obtain independent information to corroborate that information provided by the employee (i.e., seek references not supplied

by the individual). For individuals employed by the licensee for longer than three years, trustworthiness and reliability shall be determined, at a minimum, by a review of the employees' employment history with the licensee.

*c.* Service providers shall be escorted unless determined to be trustworthy and reliable by an NRC-required background investigation as an employee of a manufacturing and distribution (M&D) licensee. Written verification attesting to or certifying the person's trustworthiness and reliability shall be obtained from the manufacturing and distribution licensee providing the service.

*d.* The licensee shall document the basis for concluding that there is reasonable assurance that an individual granted unescorted access is trustworthy and reliable, and does not constitute an unreasonable risk for unauthorized use of radioactive material quantities of concern. The licensee shall maintain a list of persons approved by the licensee for unescorted access to such radioactive material and devices.

**40.54(3)** In order to ensure the safe handling, use, and control of licensed material in use and in storage, each licensee shall have a documented program to monitor and immediately detect, assess, and respond to unauthorized access to radioactive material quantities of concern and devices. Enhanced monitoring shall be provided during periods of source delivery or shipment, when the delivery or shipment exceeds 100 times the Appendix G values.

*a.* The licensee shall respond immediately to any actual or attempted theft, sabotage, or diversion of such radioactive material or of the devices. The response shall include requesting assistance from a local law enforcement agency (LLEA).

*b.* The licensee shall have a prearranged plan with the LLEA for assistance in response to an actual or attempted theft, sabotage, or diversion of such radioactive material or of the devices which is consistent in scope and timing with realistic potential vulnerability of the sources containing such radioactive material. The prearranged plan shall be updated when changes to the facility design or operation affect the potential vulnerability of the sources. Prearranged LLEA coordination is not required for temporary job sites.

*c.* The licensee shall have a dependable means to transmit information between and among the various components used to detect and identify an unauthorized intrusion, to inform the assessor, and to summon the appropriate responder.

*d.* After initiating an appropriate response to any actual or attempted theft, sabotage, or diversion of radioactive material or of the devices, the licensee shall, as promptly as possible, notify the bureau of radiological health at (515)281-3478 during normal working hours of 7:30 a.m. to 4:30 p.m., Monday through Friday. After hours and on holidays, the licensee shall call (515)323-4360 and request the homeland security and emergency management duty officer.

*e.* The licensee shall maintain documentation describing each instance of unauthorized access and any necessary corrective actions to prevent future instances of unauthorized access.

**40.54(4)** In order to ensure the safe handling, use, and control of licensed material in transportation for domestic highway and rail shipments by a carrier other than the licensee for quantities that equal or exceed those in Appendix G but are less than 100 times Appendix G quantities, per consignment, the licensee shall:

- a.* Use carriers that:
- (1) Use package tracking systems;
  - (2) Implement methods to ensure trustworthiness and reliability of drivers;
  - (3) Maintain either constant control or surveillance during transit;
  - (4) Have the capability for immediate communication to summon appropriate response or assistance;
- b.* Verify and document that the carrier employs the measures listed in paragraph "a";
- c.* Contact the recipient to coordinate the expected arrival time of the shipment;
- d.* Confirm receipt of the shipment; and
- e.* Initiate an investigation to determine the location of the licensed material if the shipment does not arrive on or about the expected arrival time. When, through the course of the investigation, it is determined that the shipment has become lost, stolen, or missing, the licensee shall immediately notify the bureau of radiological health at (515)281-3478 during normal working hours of 7:30 a.m. to

4:30 p.m., Monday through Friday. After hours and on holidays, the licensee shall call (515)323-4360 and request the homeland security and emergency management duty officer. If, after 24 hours of investigating, the location of the material still cannot be determined, the radioactive material shall be deemed missing and the licensee shall immediately notify the bureau of radiological health.

**40.54(5)** For domestic highway and rail shipments, prior to shipping licensed radioactive material that exceeds 100 times the quantities in Appendix G per consignment, the licensee shall:

*a.* Notify the NRC (Director, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, DC 20555) in writing, at least 90 days prior to the anticipated date of shipment. The NRC will issue the Order to implement the Additional Security Measures (ASMs) for the transportation of Radioactive Material Quantities of Concern (RAM QC). The licensee shall not ship the material until the ASMs for the transportation of RAM QC are implemented or the licensee is notified otherwise, in writing, by the NRC.

*b.* Once the licensee has implemented the ASMs for the transportation of RAM QC, the notification requirements of 40.54(5)“*a*” shall not apply to future shipments of licensed radioactive material that exceed 100 times the Appendix G quantities. The licensee shall implement the ASMs for the transportation of RAM QC.

**40.54(6)** If a licensee employs an M&D licensee to take possession of the licensed radioactive material and ship it under the M&D licensee’s M&D license, the requirements of 40.54(4) and 40.54(5) above shall not apply.

**40.54(7)** If the licensee is to receive radioactive material greater than or equal to the Appendix G quantities, per consignment, the licensee shall coordinate with the originating licensee to:

*a.* Establish an expected time of delivery; and

*b.* Confirm receipt of transferred radioactive material. If the material is not received at the expected time of delivery, notify the originating licensee and assist in any investigation.

**40.54(8)** In order to ensure the safe handling, use, and control of licensed material in use and in storage, each licensee that possesses mobile or portable devices containing radioactive material in quantities greater than or equal to Appendix G values shall:

*a.* For portable devices, have two independent physical controls that form tangible barriers to secure the material from unauthorized removal when the device is not under direct control and constant surveillance by the licensee.

*b.* For mobile devices:

(1) That are only moved outside of the facility (e.g., on a trailer), have two independent physical controls that form tangible barriers to secure the material from unauthorized removal when the device is not under direct control and constant surveillance by the licensee.

(2) That are only moved inside a facility, have a physical control that forms a tangible barrier to secure the material from unauthorized movement or removal when the device is not under direct control and constant surveillance by the licensee.

*c.* For devices in or on a vehicle or trailer, have a method to disable the vehicle or trailer when not under direct control and constant surveillance by the licensee.

**40.54(9)** The licensee shall retain documentation required by the increased controls for three years after the increased controls are no longer effective.

*a.* The licensee shall retain documentation regarding the trustworthiness and reliability of individual employees for three years after an individual’s employment ends.

*b.* Each time the licensee revises the list of approved persons required by 40.54(2)“*d*,” or the documented program required by 40.54(3), the licensee shall retain the previous documentation for three years after the revision.

*c.* The licensee shall retain documentation on each radioactive material carrier for three years after the licensee discontinues use of that particular carrier.

*d.* The licensee shall retain documentation on shipment coordination, notifications, and investigations for three years after the shipment or investigation is completed.

*e.* After the license is terminated or amended to reduce possession limits below the quantities of concern, the licensee shall retain all documentation required by these increased controls for three years.

**40.54(10)** Detailed information generated by the licensee that describes the physical protection of radioactive material quantities of concern is sensitive information and shall be protected from unauthorized disclosure.

*a.* The licensee shall control access to its physical protection information to those persons who have an established need to know the information and are considered to be trustworthy and reliable.

*b.* The licensee shall develop, maintain, and implement policies and procedures for controlling access to, and for proper handling and protection against unauthorized disclosure of, its physical protection information for radioactive material covered by these requirements. The policies and procedures shall include the following:

(1) General performance requirement that each person who produces, receives, or acquires the licensee's sensitive information protect the information from unauthorized disclosure;

(2) Protection of sensitive information during use, storage, and transit;

(3) Preparation, identification or marking, and transmission;

(4) Access controls;

(5) Destruction of documents;

(6) Use of automatic data processing systems; and

(7) Removal from the licensee's sensitive information category.

**641—40.55(136C) Security and control of licensed or registered sources of radiation.**

1. The licensee or registrant shall secure licensed or registered radioactive material that is stored in controlled or unrestricted areas from unauthorized removal or access.

2. The licensee or registrant shall maintain constant surveillance and use devices or administrative procedures to prevent unauthorized use of licensed or registered radioactive material that is in an unrestricted area and that is not in storage.

3. The registrant shall secure registered radiation machines from unauthorized removal.

4. The registrant shall use devices or administrative procedures to prevent unauthorized use of registered radiation machines.

5. Security requirements for portable gauges. Each portable gauge licensee shall use a minimum of two independent physical controls that form tangible barriers to secure portable gauges from unauthorized removal, whenever portable gauges are not under the control and constant surveillance of the licensee.

**641—40.56(136C) Control of sources of radiation not in storage.** Rescinded IAB 4/8/98, effective 7/1/98.

**641—40.57 to 40.59** Reserved.

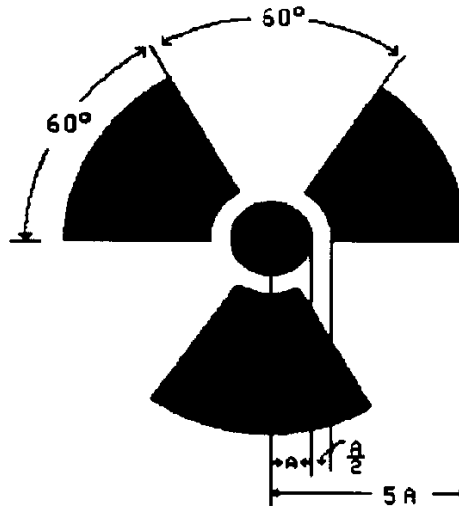
PRECAUTIONARY PROCEDURES

**641—40.60(136C) Caution signs.**

**40.60(1) Standard radiation symbol.** Unless otherwise authorized by the agency, the symbol prescribed by this rule shall use the colors magenta, or purple, or black on yellow background. The symbol prescribed is the three-bladed design as follows:

## RADIATION SYMBOL

1. Cross-hatched area is to be magenta, or purple, or black, and
2. The background is to be yellow.



**40.60(2) Exception to color requirements for standard radiation symbol.** Notwithstanding the requirements of 40.60(1), licensees are authorized to label sources, source holders, or device components containing sources of radiation that are subjected to high temperatures, with conspicuously etched or stamped radiation caution symbols and without a color requirement.

**40.60(3) Additional information on signs and labels.** In addition to the contents of signs and labels prescribed in this chapter, the licensee or registrant shall provide, on or near the required signs and labels, additional information, as appropriate, to make individuals aware of potential radiation exposures and to minimize the exposures.

**40.60(4) Improper posting or labeling.** The licensee or registrant shall ensure that adequate measures are taken to prevent improper posting or labeling.

#### 641—40.61(136C) Posting requirements.

**40.61(1) Posting of radiation areas.** The licensee or registrant shall post each radiation area with a conspicuous sign or signs bearing the radiation symbol and the words “CAUTION, RADIATION AREA”.

**40.61(2) Posting of high radiation areas.** The licensee or registrant shall post each high radiation area with a conspicuous sign or signs bearing the radiation symbol and the words “CAUTION, HIGH RADIATION AREA” or “DANGER, HIGH RADIATION AREA”.

**40.61(3) Posting of very high radiation areas.** The licensee or registrant shall post each very high radiation area with a conspicuous sign or signs bearing the radiation symbol and words “GRAVE DANGER, VERY HIGH RADIATION AREA”.

**40.61(4) Posting of airborne radioactivity areas.** The licensee shall post each airborne radioactivity area with a conspicuous sign or signs bearing the radiation symbol and the words “CAUTION, AIRBORNE RADIOACTIVITY AREA” or “DANGER, AIRBORNE RADIOACTIVITY AREA”.

**40.61(5) Posting of areas or rooms in which licensed or registered material is used or stored.** The licensee shall post each area or room in which there is used or stored an amount of licensed material exceeding ten times the quantity of such material specified in Appendix C with a conspicuous sign or signs bearing the radiation symbol and the words “CAUTION, RADIOACTIVE MATERIAL(S)” or “DANGER, RADIOACTIVE MATERIAL(S)”.

#### 641—40.62(136C) Exceptions to posting requirements.

**40.62(1)** A licensee or registrant is not required to post caution signs in areas or rooms containing sources of radiation for periods of less than eight hours, if each of the following conditions is met:

*a.* The sources of radiation are constantly attended during these periods by an individual who takes the precautions necessary to prevent the exposure of individuals to sources of radiation in excess of the limits established in this chapter; and

*b.* The area or room is subject to the licensee's or registrant's control.

**40.62(2)** Rooms or other areas in hospitals that are occupied by patients are not required to be posted with caution signs pursuant to 40.61(136C) provided that the patient could be released from licensee control pursuant to 641—subrule 41.2(27).

**40.62(3)** A room or area is not required to be posted with a caution sign because of the presence of a sealed source provided the radiation level at 30 centimeters from the surface of the sealed source container or housing does not exceed 0.005 rem (0.05 mSv) per hour.

**40.62(4)** A room or area is not required to be posted with a caution sign because of the presence of radiation machines used solely for diagnosis or simulation in the healing arts.

**40.62(5)** Rooms in hospitals or clinics that are used for teletherapy are exempt from the requirement to post caution signs under 641—40.61(136C) if:

*a.* Access to the room is controlled pursuant to 641—subrule 41.2(53); and

*b.* Personnel in attendance take necessary precautions to prevent an inadvertent exposure of workers, other patients, and members of the public to radiation in excess of the limits established in this chapter.

**641—40.63(136C) Labeling containers and radiation machines.**

**40.63(1)** The licensee shall ensure that each container of licensed material bears a durable, clearly visible label bearing the radiation symbol and the words “CAUTION, RADIOACTIVE MATERIAL” or “DANGER, RADIOACTIVE MATERIAL”. The label shall also provide information, such as the radionuclides present, an estimate of the quantity of radioactivity, the date for which the activity is estimated, radiation levels, kinds of materials, and mass enrichment, to permit individuals handling or using the containers, or working in the vicinity of the containers, to take precautions to avoid or minimize exposures.

**40.63(2)** Each licensee shall, prior to removal or disposal of empty uncontaminated containers to unrestricted areas, remove or deface the radioactive material label or otherwise clearly indicate that the container no longer contains radioactive materials.

**40.63(3)** Each registrant shall ensure that each radiation machine is labeled in a conspicuous manner which cautions individuals that radiation is produced when it is energized.

**641—40.64(136C) Exemptions to labeling requirements.** A licensee is not required to label:

**40.64(1)** Containers holding licensed materials in quantities less than the quantities listed in Appendix C; or

**40.64(2)** Containers holding licensed material in concentrations less than those specified in Table III of Appendix B; or

**40.64(3)** Containers attended by an individual who takes the precautions necessary to prevent the exposure of individuals in excess of the limits established by this chapter; or

**40.64(4)** Containers when they are in transport and packaged and labeled in accordance with the rules of the U.S. Department of Transportation;<sup>1</sup> or

**40.64(5)** Containers that are accessible only to individuals authorized to handle or use them, or to work in the vicinity of the containers, if the contents are identified to these individuals by a readily available written record. Examples of containers of this type are containers in locations such as water-filled canals, storage vaults, or hot cells. The record shall be retained as long as the containers are in use for the purpose indicated on the record; or

**40.64(6)** Installed manufacturing or process equipment, such as piping and tanks.

<sup>1</sup> Labeling of packages containing radioactive materials is required by the U.S. Department of Transportation if the amount and type of radioactive material exceeds the limits for an excepted quantity or article as defined and limited by U.S. Department of Transportation regulations 49 CFR 173.403(m) and (w) and 173.421-424.



**641—40.65(136C) Procedures for receiving and opening packages.**

**40.65(1)** Each licensee who expects to receive a package containing quantities of radioactive material in excess of a Type A quantity shall make arrangements to receive:

- a. The package when the carrier offers it for delivery; or
- b. The notification of the arrival of the package at the carrier's terminal and to take possession of the package expeditiously.

**40.65(2)** Each licensee shall:

a. Monitor the external surfaces of a labeled<sup>1</sup> package for radioactive contamination unless the package contains only radioactive material in the form of gas or in special form as defined in 641—Chapter 38;

b. Monitor the external surfaces of a labeled<sup>1</sup> package for radiation levels unless the package contains quantities of radioactive material that are less than or equal to the Type A quantity; and

c. Monitor all packages known to contain radioactive material for radioactive contamination and radiation levels if there is evidence of degradation of package integrity, such as packages that are crushed, wet, or damaged.

**40.65(3)** The licensee shall perform the monitoring required by 40.65(2) as soon as practicable after receipt of the package, but not later than three hours after the package is received at the licensee's facility if it is received during the licensee's normal working hours, or not later than three hours from the beginning of the next working day if it is received after working hours.

**40.65(4)** The licensee shall immediately notify the final delivery carrier and, by telephone and telegram, mailgram, or facsimile, the Agency when:

a. Removable radioactive surface contamination exceeds the limits of 49 CFR 173.443; or

b. External radiation levels exceed the limits of 10 CFR 71.47 as set forth in rule 641—39.5(136C).

**40.65(5)** Each licensee shall:

a. Establish, maintain, and retain written procedures for safely opening packages in which radioactive material is received; and

b. Ensure that the procedures are followed and that due consideration is given to special instructions for the type of package being opened.

**40.65(6)** Licensees transferring special form sources in vehicles owned or operated by the licensee or registrant to and from a work site are exempt from the contamination monitoring requirements of 40.65(2), but are not exempt from the monitoring requirement in 40.65(2), for measuring radiation levels that ensure that the source is still properly lodged in its shield.

<sup>1</sup> Labeled with a Radioactive e White I, Yellow II, or Yellow III label as specified in U.S. Department of Transportation regulations 49 CFR 172.403 and 172.436-440.

**641—40.66 to 40.69** Reserved.

## WASTE DISPOSAL

**641—40.70(136C) General requirements.**

**40.70(1)** A licensee shall dispose of licensed material only:

a. By transfer to an authorized recipient as provided in 40.74(136C) or 641—39.4(136C), or to the U.S. Department of Energy; or

b. By decay in storage; or

c. By release in effluents within the limits in 40.72(1) "d"; or

d. As authorized pursuant to 40.71(136C), 40.72(136C), 40.73(136C), or 40.74(136C).

**40.70(2)** A person shall be specifically licensed to receive waste containing licensed material from other persons for:

a. Treatment prior to disposal; or

b. Treatment or disposal by incineration; or

c. Decay in storage; or

- d.* Storage until transferred to a storage or disposal facility authorized to receive the waste.

**641—40.71(136C) Method for obtaining approval of proposed disposal procedures.** A licensee or applicant for a license may apply to the Agency for approval of proposed procedures, not otherwise authorized in these rules, to dispose of licensed material generated in the licensee's operations. Each application shall include:

**40.71(1)** A description of the waste containing licensed material to be disposed of, including the physical and chemical properties that have an impact on risk evaluation, and the proposed manner and conditions of waste disposal; and

**40.71(2)** An analysis and evaluation of pertinent information on the nature of the environment; and

**40.71(3)** The nature and location of other potentially affected facilities; and

**40.71(4)** Analyses and procedures to ensure that doses are maintained ALARA and within the dose limits in this chapter.

**641—40.72(136C) Disposal by release into sanitary sewerage.**

**40.72(1)** A licensee may discharge licensed material into sanitary sewerage if each of the following conditions is satisfied:

*a.* The material is readily soluble, or is readily dispersible biological material, in water; and

*b.* The quantity of licensed radioactive material that the licensee releases into the sewer in one month divided by the average monthly volume of water released into the sewer by the licensee does not exceed the concentration listed in Table III of Appendix B; and

*c.* If more than one radionuclide is released, the following conditions must also be satisfied:

(1) The licensee shall determine the fraction of the limit in Table III of Appendix B represented by discharges into sanitary sewerage by dividing the actual monthly average concentration of each radionuclide released by the licensee into the sewer by the concentration of that radionuclide listed in Table III of Appendix B; and

(2) The sum of the fractions for each radionuclide required by 40.72(1) "c"(1) does not exceed unity; and

*d.* The total quantity of licensed radioactive material that the licensee releases into the sanitary sewerage in a year does not exceed 5 Ci (185 GBq) of hydrogen-3, 1 Ci (37 GBq) of carbon-14, and 1 Ci (37 GBq) of all other radioactive materials combined.

**40.72(2)** Excreta from individuals undergoing medical diagnosis or therapy with radioactive material are not subject to the limitations contained in 40.72(1).

**641—40.73(136C) Treatment or disposal by incineration.** A licensee may treat or dispose of licensed materials by incineration only in the amounts and forms specified in 40.74(136C) or as specifically approved by the Agency pursuant to 40.71(136C).

**641—40.74(136C) Disposal of specific wastes.**

**40.74(1)** A licensee may dispose of the following licensed material as if it were not radioactive:

*a.* 0.05  $\mu\text{Ci}$  (1.85 kBq), or less, of hydrogen-3 or carbon-14 per gram of medium used for liquid scintillation counting; and

*b.* 0.05  $\mu\text{Ci}$  (1.85 kBq), or less, of hydrogen-3 or carbon-14 per gram of animal tissue, averaged over the weight of the entire animal.

**40.74(2)** A licensee shall not dispose of tissue pursuant to 40.74(1) "b" in a manner that would permit its use either as food for humans or as animal feed.

**40.74(3)** The licensee shall maintain records in accordance with 40.88(136C).

**641—40.75(136C) Transfer for disposal and manifests.**

**40.75(1)** Any licensee shipping radioactive waste intended for ultimate disposal at a licensed land disposal facility must document the information required on the Uniform Low-Level Radioactive Waste Manifest and transfer this recorded manifest information to the intended consignee in accordance with Appendix D of this chapter.

**40.75(2)** Each shipment manifest must include a certification by the waste generator as specified in Section II of Appendix D of this chapter.

**40.75(3)** Each person involved in the transfer for disposal and disposal of waste, including the waste generator, waste collector, waste processor, and disposal facility operator, shall comply with the requirements specified in Section III of Appendix D of this chapter.

**641—40.76(136C) Compliance with environmental and health protection regulations.** Nothing in 40.70(136C), 40.71(136C), 40.72(136C), 40.73(136C), 40.74(136C), or 40.75(136C) relieves the licensee or registrant from complying with other applicable federal, state and local regulations governing any other toxic or hazardous properties of materials that may be disposed of to 40.70(136C), 40.71(136C), 40.72(136C), 40.73(136C), 40.74(136C), or 40.75(136C).

**641—40.77 to 40.79** Reserved.

#### RECORDS

**641—40.80(136C) General provisions.**

**40.80(1)** Each licensee or registrant shall use the special units curie, rad, rem and roentgen, counts per minute (cpm), disintegrations per minute (dpm), or the SI units becquerel, gray, sievert and coulomb per kilogram, including multiples and subdivisions, and shall clearly indicate the units of all quantities on records required by this chapter.

**40.80(2)** The licensee or registrant shall make a clear distinction among the quantities entered on the records required by this chapter, such as, total effective dose equivalent, total organ dose equivalent, shallow dose equivalent, lens dose equivalent, deep dose equivalent, or committed effective dose equivalent.

**40.80(3)** In the records required by this chapter, the licensee may record quantities in SI units in parentheses following each of the units specified in 40.80(1). However, all quantities must be recorded as stated in 40.80(1).

**40.80(4)** Notwithstanding the requirements of 40.80(1), when recording information on shipment manifests, as required in 641—40.75(136C), information must be recorded in the International System of Units (SI) or in SI and units as specified in 40.80(1).

**40.80(5)** Notwithstanding the requirements of 40.80(1), records of removable radioactive surface contamination on packages shall be recorded in disintegrations per minute (dpm).

**641—40.81(136C) Records of radiation protection programs.**

**40.81(1)** Each licensee or registrant shall maintain records of the radiation protection program, including:

- a. The provisions of the program; and
- b. Audits and other reviews of program content and implementation.

**40.81(2)** The licensee or registrant shall retain the records required by 40.81(1) “a” until the Agency terminates each pertinent license or registration requiring the record. The licensee or registrant shall retain the records required by 40.81(1) “b” for three years after the record is made.

**641—40.82(136C) Records of surveys.**

**40.82(1)** Each licensee or registrant shall maintain records showing the results of surveys and calibrations required by 40.36(136C) and 40.65(2). The licensee or registrant shall retain these records for three years after the record is made.

**40.82(2)** The licensee or registrant shall retain each of the following records until the Agency terminates each pertinent license or registration requiring the record:

- a. Records of the results of surveys to determine the dose from external sources of radiation used, in the absence of or in combination with individual monitoring data, in the assessment of individual dose equivalents; and

b. Records of the results of measurements and calculations used to determine individual intakes of radioactive material and used in the assessment of internal dose; and

c. Records showing the results of air sampling, surveys, and bioassays required pursuant to 40.50(1)“c”(1) and 40.50(1)“c”(2); and

d. Records of the results of measurements and calculations used to evaluate the release of radioactive effluents to the environment.

**40.82(3)** Upon termination of the license or registration, the licensee or registrant shall permanently store records required in 641—40.82(136C) or shall make provisions with the agency for transfer to the agency.

**641—40.83(136C) Records of tests for leakage or contamination of sealed sources.** Records of tests for leakage or contamination of sealed sources required by 40.32(136C) shall be kept in units of microcurie or becquerel and maintained for inspection by the agency for five years after the records are made.

**641—40.84(136C) Records of prior occupational dose.**

**40.84(1)** The licensee or registrant shall retain the records of prior occupational dose and exposure history as specified in 40.19(136C) until the agency terminates each pertinent license or registration requiring this record. The licensee or registrant shall retain records used in preparing the record required in 40.84(136C) for three years after the record is made.

**40.84(2)** Upon termination of the license or registration, the licensee or registrant shall permanently store records required in 40.84(136C) or shall make provisions with the agency for transfer to the agency.

**641—40.85(136C) Records of planned special exposures.**

**40.85(1)** For each use of the provisions of 40.20(136C) for planned special exposures, the licensee or registrant shall maintain records that describe:

- a. The exceptional circumstances requiring the use of a planned special exposure; and
- b. The name of the management official who authorized the planned special exposure and a copy of the signed authorization; and
- c. What actions were necessary; and
- d. Why the actions were necessary; and
- e. What precautions were taken to assure that doses were maintained ALARA; and
- f. What individual and collective doses were expected to result; and
- g. The doses actually received in the planned special exposure.

**40.85(2)** The licensee or registrant shall retain the records until the agency terminates each pertinent license or registration requiring these records.

**40.85(3)** Upon termination of the license or registration, the licensee or registrant shall permanently store records required in 40.85(136C) or shall make provisions with the agency for transfer to the agency.

**641—40.86(136C) Records of individual monitoring results.**

**40.86(1) Record-keeping requirement.** Each licensee or registrant shall maintain records of doses received by all individuals for whom monitoring was required pursuant to 40.37(136C), and records of doses received during planned special exposures, accidents, and emergency conditions. Assessments of dose equivalent and records made using units in effect on or before January 1, 1994, need not be changed. These records shall include, when applicable:

- a. The deep dose equivalent to the whole body, eye dose equivalent, shallow dose equivalent to the skin, and shallow dose equivalent to the extremities; and
- b. The estimated intake of radionuclides, see 40.16(136C); and
- c. The committed effective dose equivalent assigned to the intake of radionuclides; and
- d. The specific information used to calculate the committed effective dose equivalent pursuant to 40.18(3); and
- e. The total effective dose equivalent when required by 40.16(136C); and

*f.* The total of the deep dose equivalent and the committed dose to the organ receiving the highest total dose.

**40.86(2) *Record-keeping frequency.*** The licensee or registrant shall make entries of the records specified in 40.86(1) at intervals not to exceed one year.

**40.86(3) *Record-keeping format.*** The licensee or registrant shall maintain the records specified in 40.86(1) in clear and legible form.

**40.86(4) *Embryo/Fetus records.*** The licensee or registrant shall maintain the records of dose to an embryo/fetus with the records of dose to the declared pregnant woman. The declaration of pregnancy, including the estimated date of conception, shall also be kept on file, but may be maintained separately from the dose records.

**40.86(5) *Retention during license or registration.*** The licensee or registrant shall retain each required form or record until the agency terminates each pertinent license or registration requiring the record.

**40.86(6) *Retention after termination.*** Upon termination of the license or registration, the licensee or registrant shall permanently store records required in 40.86(136C) or shall make provision with the agency for transfer to the agency.

#### **641—40.87(136C) Records of dose to individual members of the public.**

**40.87(1)** Each licensee or registrant shall maintain records sufficient to demonstrate compliance with the dose limit for individual members of the public. See 40.26(136C).

**40.87(2)** The licensee or registrant shall retain the records required by this rule until the agency terminates each pertinent license or registration requiring the record.

#### **641—40.88(136C) Records of waste disposal.**

**40.88(1)** Each licensee shall maintain records of the disposal of licensed materials made pursuant to 40.71(136C), 40.72(136C), 40.73(136C), 40.74(136C), and disposal or burial in soil.

**40.88(2)** The licensee shall retain the records required by 40.88(1) until the agency terminates each pertinent license or registration requiring the record.

#### **641—40.89(136C) Records of testing entry control devices for very high radiation areas.**

**40.89(1)** Each licensee or registrant shall maintain records of tests made pursuant to 40.44(2) "j" on entry control devices for very high radiation areas. These records must include the date, time, and results of each such test of function.

**40.89(2)** The licensee or registrant shall retain the records required by 40.89(1) for three years after the record is made.

#### **641—40.90(136C) Form of records.**

**40.90(1)** Each record required by Chapter 40 shall be legible throughout the specified retention period. The record shall be the original or a reproduced copy or a microform provided that the copy or microform is authenticated by authorized personnel and that the microform is capable of producing a clear copy throughout the required retention period, or the record may also be stored in electronic media with the capability for producing legible, accurate, and complete records during the required retention period. Records, such as letters, drawings, and specifications, shall include all pertinent information, such as stamps, initials, and signatures. The licensee or registrant shall maintain adequate safeguards against tampering with and loss of records.

**40.90(2)** The licensee or registrant shall retain the records required by Chapter 40 until the agency terminates each pertinent license or registration requiring the record.

**641—40.91 to 40.94** Reserved.

## REPORTS

**641—40.95(136C) Reports of stolen, lost, or missing licensed or registered sources of radiation.**

**40.95(1)** Telephone reports. Each licensee or registrant shall report to the agency by telephone as follows:

*a.* Immediately after its occurrence becomes known to the licensee, stolen, lost, or missing licensed radioactive material in an aggregate quantity equal to or greater than 1,000 times the quantity specified in Appendix C under such circumstances that it appears to the licensee that an exposure could result to individuals in unrestricted areas; or

*b.* Within 30 days after its occurrence becomes known to the licensee, lost, stolen, or missing licensed radioactive material in quantity greater than ten times the quantity specified in Appendix C that is still missing.

*c.* Immediately after its occurrence becomes known to the registrant, a stolen, lost, or missing radiation machine.

*d.* Rescinded IAB 3/30/05, effective 5/4/05.

**40.95(2)** Written reports. Each licensee or registrant required to make a report pursuant to 40.95(1) shall, within 30 days after making the telephone report, make a written report to the agency setting forth the following information:

*a.* A description of the licensed or registered source of radiation involved, including, for radioactive material, the kind, quantity, and chemical and physical form; and, for radiation machines, the manufacturer, model and serial number, type and maximum energy of radiation emitted; and

*b.* A description of the circumstances under which the loss or theft occurred; and

*c.* A statement of disposition, or probable disposition, of the licensed or registered source of radiation involved; and

*d.* Exposures of individuals to radiation, circumstances under which the exposures occurred, and the possible total effective dose equivalent to persons in unrestricted areas; and

*e.* Actions that have been taken, or will be taken, to recover the source of radiation; and

*f.* Procedures or measures that have been, or will be, adopted to ensure against a recurrence of the loss or theft of licensed or registered sources of radiation.

**40.95(3)** Subsequent to filing the written report, the licensee or registrant shall also report additional substantive information on the loss or theft within 30 days after the licensee or registrant learns of such information.

**40.95(4)** The licensee or registrant shall prepare any report filed with the agency pursuant to 40.95(136C) so that names of individuals who may have received exposure to radiation are stated in a separate and detachable portion of the report.

**641—40.96(136C) Notification of incidents.**

**40.96(1)** Immediate notification. Notwithstanding other requirements for notification, each licensee or registrant shall immediately report each event involving a source of radiation possessed by the licensee or registrant that may have caused or threatens to cause any of the following conditions:

*a.* An individual to receive:

(1) A total effective dose equivalent of 25 rem (0.25 Sv) or more; or

(2) A lens dose equivalent of 75 rem (0.75 Sv) or more; or

(3) A shallow dose equivalent to the skin or extremities of 250 rad (2.5 Gy) or more; or

*b.* The release of radioactive material, inside or outside of a restricted area, so that, had an individual been present for 24 hours, the individual could have received an intake five times the annual limit on intake. This provision does not apply to locations where personnel are not normally stationed during routine operations, such as hot-cells or process enclosures.

*c.* In addition to the requirements of paragraphs “*a*” and “*b*” above, each licensee shall notify the Iowa department of public health as soon as possible but not later than four hours after the discovery of an event that prevents immediate protective actions necessary to avoid exposures to radiation or radioactive

materials that could exceed regulatory limits or releases of licensed material that could exceed regulatory limits (events may include fires, explosions, toxic gas releases, and other such events).

**40.96(2)** Twenty-four-hour notification. Each licensee or registrant shall, within 24 hours of discovery of the event, report to the agency each event involving loss of control of a licensed or registered source of radiation possessed by the licensee or registrant that may have caused, or threatens to cause, any of the following conditions:

*a.* An individual to receive, in a period of 24 hours:

- (1) A total effective dose equivalent exceeding 5 rem (0.05 Sv); or
- (2) A lens dose equivalent exceeding 15 rem (0.15 Sv); or
- (3) A shallow dose equivalent to the skin or extremities exceeding 50 rem (0.5 Sv); or

*b.* The release of radioactive material, inside or outside of a restricted area, so that, had an individual been present for 24 hours, the individual could have received an intake in excess of one occupational ALI. This provision does not apply to locations where personnel are not normally stationed during routine operations, such as hot-cells or process enclosures.

*c.* In addition to the requirements of paragraphs “*a*” and “*b*” above, each licensee shall notify the Iowa department of public health within 24 hours after the discovery of any of the following events involving licensed material:

(1) An unplanned contamination event that:

1. Requires access to the contaminated area, by workers or the public, to be restricted for more than 24 hours by imposing additional radiological controls or by prohibiting entry into the area;
2. Involves a quantity of material greater than five times the lowest annual limit on intake specified in Appendix B for the material; and
3. Has access to the area restricted for a reason other than to allow isotopes with a half-life of less than 24 hours to decay prior to decontamination.

(2) An event in which equipment is disabled or fails to function as designed when:

1. The equipment is required by regulation or license condition to prevent releases exceeding regulatory limits, to prevent exposures to radiation and radioactive materials exceeding regulatory limits, or to mitigate the consequences of an accident;
2. The equipment is required to be available and operable when it is disabled or fails to function; and
3. No redundant equipment is available and operable to perform the required safety function.

(3) An event that requires unplanned medical treatment at a medical facility of an individual with spreadable radioactive contamination on the individual’s clothing or body.

(4) An unplanned fire or explosion damaging any licensed material or any device, container, or equipment containing licensed material when:

1. The quantity of material involved is greater than five times the lowest annual limit on intake specified in Appendix B for the material; and
2. The damage affects the integrity of the licensed material or its container.

**40.96(3)** The licensee or registrant shall prepare each report filed with the agency pursuant to 40.96(136C) so that names of individuals who have received exposure to sources of radiation are stated in a separate and detachable portion of the report.

**40.96(4)** Licensees or registrants shall make the reports required by 40.96(1) and 40.96(2) to the agency by telephone, telegram, mailgram, or facsimile.

*a.* Licensees or registrants making initial reports to the Iowa department of public health shall to the extent that the information is available at the time of notification include:

- (1) The caller’s name and call-back telephone number;
- (2) A description of the event, including date and time;
- (3) The exact location of the event;
- (4) The isotopes, quantities, and chemical and physical form of the licensed material involved; and
- (5) Any personnel radiation exposure data available.

*b.* Each licensee or registrant who makes a report required by 40.96(1) or 40.96(2) shall submit a written follow-up report within 30 days of the initial report. Written reports prepared pursuant to other

rules may be submitted to fulfill this requirement if the reports contain all of the necessary information. These written reports must be sent to the Iowa Department of Public Health, Bureau of Radiological Health, Lucas State Office Building, Des Moines, Iowa 50319. The reports must include the following:

- (1) A description of the event, including the probable cause and the manufacturer and model number (if applicable) of any equipment that failed or malfunctioned;
- (2) The exact location of the event;
- (3) The isotopes, quantities, and chemical and physical form of the licensed material involved;
- (4) Date and time of the event;
- (5) Corrective actions taken or planned and the results of any evaluations or assessments; and
- (6) The extent of exposure of individuals to radiation or to radioactive materials without identification of individuals by name.

**40.96(5)** The provisions of 641—40.96(136C) do not apply to doses that result from planned special exposures, provided such doses are within the limits for planned special exposures and are reported pursuant to 641—40.98(136C).

**641—40.97(136C) Reports of exposures, radiation levels, and concentrations of radioactive material exceeding the constraints or limits.**

**40.97(1)** Reportable events. In addition to the notification required by 40.96(136C), each licensee or registrant shall submit a written report within 30 days after learning of any of the following occurrences:

- a. Incidents for which notification is required by 40.96(136C); or
- b. Doses in excess of any of the following:
  - (1) The occupational dose limits for adults in 40.15(136C); or
  - (2) The occupational dose limits for a minor in 40.21(136C); or
  - (3) The limits for an individual member of the public in 40.26(136C); or
  - (4) Any applicable limit in the license or registration; or
  - (5) The ALARA constraints for air emissions established under 641—40.10(136C); or
  - (6) The limits for an embryo/fetus of a declared pregnant woman in 40.22(136C).
- c. Levels of radiation or concentrations of radioactive material in:
  - (1) A restricted area in excess of applicable limits in the license or registration; or
  - (2) An unrestricted area in excess of ten times the applicable limit set forth in this chapter or in the license or registration, whether or not involving exposure of any individual in excess of the limits in 40.26(136C); or
- d. For licensees subject to the provisions of U.S. Environmental Protection Agency's generally applicable environmental radiation standards in 40 CFR 190, levels of radiation or releases of radioactive material in excess of those standards, or of license conditions related to those standards.

**40.97(2)** Contents of reports.

a. Each report required by 40.97(1) shall describe the extent of exposure of individuals to radiation and radioactive material, including, as appropriate:

- (1) Estimates of each individual's dose; and
  - (2) The levels of radiation and concentrations of radioactive material involved; and
  - (3) The cause of the elevated exposures, dose rates, or concentrations; and
  - (4) Corrective steps taken or planned to ensure against a recurrence, including the schedule for achieving conformance with applicable limits, ALARA constraints, generally applicable environmental standards, and associated license conditions. Each report filed pursuant to this paragraph must include the name, social security number, and date of birth for each occupationally overexposed individual. The report must be prepared so that this information is stated in a separate and detachable part of the report.
- b. Each report filed pursuant to 40.97(1) shall include for each individual exposed: the name, social security account number, and date of birth. With respect to the limit for the embryo/fetus in 40.22(136C), the identifiers should be those of the declared pregnant woman. The report shall be prepared so that this information is stated in a separate and detachable portion of the report.



**40.97(3)** All licensees or registrants who make reports pursuant to 40.97(1) to the agency shall also provide a copy of the report to the individual. Transmittal shall be at the same time as the transmittal to the agency.

**641—40.98(136C) Reports of planned special exposures.** The licensee or registrant shall submit a written report to the agency within 30 days following any planned special exposure conducted in accordance with 40.20(136C) informing the agency that a planned special exposure was conducted and indicating the date the planned special exposure occurred and the information required by 40.85(136C).

**641—40.99(136C) Reports of transactions involving nationally tracked sources.** Each licensee who manufactures, transfers, receives, disassembles, or disposes of a nationally tracked source shall complete and submit a National Source Tracking Transaction Report as specified in subrules 40.99(1) to 40.99(5) for each type of transaction.

**40.99(1)** Each licensee that manufactures a nationally tracked source shall complete and submit a National Source Tracking Transaction Report. The report must include the following information:

- a. The name, address, and license number of the reporting licensee;
- b. The name of the individual preparing the report;
- c. The manufacturer, model, and serial number of the source;
- d. The radioactive material in the source;
- e. The initial source strength in becquerels (curies) at the time of manufacture; and
- f. The manufacture date of the source.

**40.99(2)** Each licensee that transfers a nationally tracked source to another person shall complete and submit a National Source Tracking Transaction Report. The report must include the following information:

- a. The name, address, and license number of the reporting licensee;
- b. The name of the individual preparing the report;
- c. The name and license number of the recipient facility and the shipping address;
- d. The manufacturer, model, and serial number of the source or, if not available, other information to uniquely identify the source;
- e. The radioactive material in the source;
- f. The initial or current source strength in becquerels (curies);
- g. The date for which the source strength is reported;
- h. The shipping date;
- i. The estimated arrival date; and
- j. For nationally tracked sources transferred as waste under a Uniform Low-Level Radioactive Waste Manifest, the waste manifest number and the container identification with the nationally tracked source.

**40.99(3)** Each licensee that receives a nationally tracked source shall complete and submit a National Source Tracking Transaction Report. The report must include the following information:

- a. The name, address, and license number of the reporting licensee;
- b. The name of the individual preparing the report;
- c. The name, address, and license number of the person that provided the source;
- d. The manufacturer, model, and serial number of the source or, if not available, other information to uniquely identify the source;
- e. The radioactive material in the source;
- f. The initial or current source strength in becquerels (curies);
- g. The date for which the source strength is reported;
- h. The date of receipt; and
- i. For material received under a Uniform Low-Level Radioactive Waste Manifest, the waste manifest number and the container identification with the nationally tracked source.

**40.99(4)** Each licensee that disassembles a nationally tracked source shall complete and submit a National Source Tracking Transaction Report. The report must include the following information:

- a. The name, address, and license number of the reporting licensee;
- b. The name of the individual preparing the report;
- c. The manufacturer, model, and serial number of the source or, if not available, other information to uniquely identify the source;
- d. The radioactive material in the source;
- e. The initial or current source strength in becquerels (curies);
- f. The date for which the source strength is reported; and
- g. The disassemble date of the source.

**40.99(5)** Each licensee that disposes of a nationally tracked source shall complete and submit a National Source Tracking Transaction Report. The report must include the following information:

- a. The name, address, and license number of the reporting licensee;
- b. The name of the individual preparing the report;
- c. The waste manifest number;
- d. The container identification with the nationally tracked source;
- e. The date of disposal; and
- f. The method of disposal.

**40.99(6)** Reports discussed in subrules 40.99(1) to 40.99(5) must be submitted by the close of the next business day after the transaction. A single report may be submitted for multiple sources and transactions. The reports must be submitted to the National Source Tracking System by using:

- a. The on-line National Source Tracking System;
- b. Electronically using a computer-readable format;
- c. By facsimile;
- d. By mail to the address on the National Source Tracking Transaction Report Form (NRC Form 748); or
- e. By telephone with follow-up by facsimile or mail.

**40.99(7)** Each licensee shall correct any error in previously filed reports or file a new report for any missed transaction within five business days of the discovery of the error or missed transaction. Such errors may be detected by a variety of methods such as administrative reviews or by physical inventories required by regulation. In addition, each licensee shall reconcile the inventory of nationally tracked sources possessed by the licensee against that licensee's data in the National Source Tracking System. The reconciliation must be conducted during the month of January in each year. The reconciliation process must include resolving any discrepancies between the National Source Tracking System and the actual inventory by filing the reports identified by subrules 40.99(1) to 40.99(5). By January 31 of each year, each licensee must submit to the National Source Tracking System confirmation that the data in the National Source Tracking System is correct.

**40.99(8)** Each licensee that possesses Category 1 nationally tracked sources shall report its initial inventory of Category 1 nationally tracked sources to the National Source Tracking System by January 31, 2009. Each licensee that possesses Category 2 nationally tracked sources shall report its initial inventory of Category 2 nationally tracked sources to the National Source Tracking System by January 31, 2009. The information may be submitted by using any of the methods identified in subrule 40.99(6). The initial inventory report must include the following information:

- a. The name, address, and license number of the reporting licensee;
- b. The name of the individual preparing the report;
- c. The manufacturer, model, and serial number of each nationally tracked source or, if not available, other information to uniquely identify the source;
- d. The radioactive material in the sealed source;
- e. The initial or current source strength in becquerels (curies); and
- f. The date for which the source strength is reported.

**641—40.100(136C) Reports of individual monitoring.**

**40.100(1)** This section applies to each person licensed or registered by the agency to:

- a.* Possess or use sources of radiation for purposes of industrial radiography pursuant to 641—39.4(136C) and 641—Chapter 45; or
- b.* Receive radioactive waste from other persons for disposal pursuant to 10 CFR Part 61 of federal regulations or appropriate other Agreement State regulations; or
- c.* Possess or use at any time, for processing or manufacturing for distribution pursuant to 641—39.4(136C) or 641—41.2(136C), radioactive material in quantities exceeding any one of the following quantities:

Radionuclide	Activity <sup>a</sup>	
	Ci	GBq
Cesium-137	1	37
Cobalt-60	1	37
Gold-198	100	3,700
Iodine-131	1	37
Iridium-192	10	370
Krypton-85	1,000	37,000
Promethium-147	10	370
Technetium-99m	1,000	37,000

<sup>a</sup> The agency may require as a license condition, or by rule, regulation, or order pursuant to 40.105(136C), reports from licensees or registrants who are licensed or registered to use radionuclides not on this list, in quantities sufficient to cause comparable radiation levels.

**40.100(2)** Each licensee or registrant in a category listed in 40.100(1) shall submit an annual report of the results of individual monitoring carried out by the licensee or registrant for each individual for whom monitoring was required by 40.36(136C) during that year. The licensee or registrant may include additional data for individuals for whom monitoring was provided but not required.

**40.100(3)** The licensee or registrant shall file the report required by 40.100(2), covering the preceding year, on or before April 30 of each year. The licensee or registrant shall submit the report to the agency.

**641—40.101(136C) Notifications and reports to individuals.**

**40.101(1)** Requirements for notification and reports to individuals of exposure to radiation or radioactive material are specified in 641—40.112(136C).

**40.101(2)** When a licensee or registrant is required pursuant to 40.97(136C), 40.98(136C), or 40.100(136C) to report to the agency any exposure of an identified occupationally exposed individual, or an identified member of the public, to radiation or radioactive material, the licensee or registrant shall also provide a copy of the report submitted to this agency to the individual. Such notice shall be transmitted at a time not later than the transmittal to the agency, and shall comply with the provisions of 40.112(1).

**641—40.102(136C) Reports of leaking or contaminated sealed sources.** The licensee shall file a report within five days with the agency if the test for leakage or contamination required pursuant to 40.32(136C) indicates a sealed source is leaking or contaminated. The report shall include the equipment involved, the test results and the corrective action taken.

**641—40.103 and 40.104** Reserved.

ADDITIONAL REQUIREMENTS

**641—40.105(136C) Vacating premises.** Each specific licensee shall, no less than 30 days before vacating or relinquishing possession or control of premises which may have been contaminated with radioactive material as a result of their activities, notify the agency in writing of intent to vacate. When

deemed necessary by the agency, the licensee shall decontaminate the premises in such a manner as the agency may specify.

**641—40.106 to 40.109** Reserved.

NOTICES, INSTRUCTIONS, AND REPORTS TO WORKERS; INSPECTIONS

**641—40.110(136C) Posting of notices to workers.**

**40.110(1)** Each licensee or registrant, except those registrants with diagnostic X-ray systems, shall post current copies of the following documents:

- a. This subrule and 641—Chapter 40;
- b. The license, certificate of registration, conditions or documents incorporated into the license by reference and amendments thereto;
- c. The operating procedures applicable to activities under the license or registration; and
- d. Any notice of violation involving radiological working conditions, proposed imposition of civil penalty, or order issued pursuant to 641—Chapter 38, and any response from the licensee or registrant.

**40.110(2)** If posting of a document specified in 40.110(1) “a,” 40.110(1) “b” and 40.110(1) “c” is not practical, the licensee or registrant may post a notice which describes the document and states where it may be examined.

**40.110(3)** Agency Form “Notice to Employees” shall be posted by each licensee or registrant.

**40.110(4)** Agency documents posted pursuant to 40.110(1) “d” shall be posted within two working days after receipt of the documents from the agency; the licensee’s or registrant’s response, if any, shall be posted within two working days after dispatch from the licensee or registrant. Such documents shall remain posted for a minimum of five working days or until action correcting the violation has been completed, whichever is later.

**40.110(5)** Documents, notices, or forms posted pursuant to 40.110(1) shall appear in a sufficient number of places to permit individuals engaged in work under the license or registration to observe them on the way to or from any particular work location to which the document applies, shall be conspicuous, and shall be replaced if defaced or altered.

**641—40.111(136C) Instructions to workers.**

**40.111(1)** All individuals who in the course of employment are likely to receive in a year an occupational dose in excess of 100 mrem (1 mSv):

- a. Shall be kept informed of the storage, transfer, or use of sources of radiation;
- b. Shall be instructed in the health protection problems associated with exposure to radiation or radioactive material to the individual and potential offspring, in precautions or procedures to minimize exposure, and in the purposes and functions of protective devices employed;
- c. Shall be instructed in, and required to observe, to the extent within the worker’s control, the applicable provisions of these rules and licenses for the protection of personnel from exposures to radiation or radioactive material occurring in such areas;
- d. Shall be instructed of their responsibility to report promptly to the licensee or registrant any condition which may constitute, lead to, or cause a violation of the Act, these rules, and licenses or unnecessary exposure to radiation or radioactive material;
- e. Shall be instructed in the appropriate response to warnings made in the event of any unusual occurrence or malfunction that may involve exposure to radiation or radioactive material; and
- f. Shall be advised as to the radiation exposure reports which workers shall be furnished pursuant to 641—40.112(136C).
- g. The instruction in “b” through “f” above shall be conducted at least annually.
- h. Shall be commensurate with potential radiological health protection problems present in the workplace.

**40.111(2)** In determining those individuals subject to the requirements of 40.111(1), consideration must be given to assigning activities during normal and abnormal situations involving exposure to

sources of radiation which can reasonably be expected to occur during the life of the facility. The extent of these instructions must be commensurate with potential radiological health protection problems present in the workplace.

**641—40.112(136C) Notifications and reports to individuals.**

**40.112(1)** Radiation exposure data for an individual and the results of any measurements, analyses, and calculations of radioactive material deposited or retained in the body of an individual shall be reported to the individual as specified in subrule 40.112(2). The information reported shall include data and results obtained pursuant to these rules, orders, or license conditions, as shown in records maintained by the licensee or registrant pursuant to 40.86(136C). Each notification and report shall:

- a. Be in writing;
- b. Include appropriate identifying data such as the name of the licensee or registrant, the name of the individual, and the individual's identification number, preferably social security number;
- c. Include the individual's exposure information; and
- d. Contain the following statement:

"This report is furnished to you under the provisions of 40.112(136C) of Iowa's Radiation Machine and Radioactive Materials rules. You should preserve this report for further reference."

**40.112(2)** Each licensee or registrant shall advise each worker annually of the worker's dose as shown in records maintained by the licensee or registrant pursuant to 40.86(136C).

**40.112(3)** Each licensee or registrant shall furnish a report of the worker's exposure to sources of radiation at the request of a worker formerly engaged in activities controlled by the licensee or registrant. The report shall include the dose record for each year the worker was required to be monitored pursuant to 40.37(136C). Such report shall be furnished within 30 days from the date of the request, or within 30 days after the dose of the individual has been determined by the licensee or registrant, whichever is later. The report shall cover the period of time that the worker's activities involved exposure to sources of radiation and shall include the dates and locations of work under the license or registration in which the worker participated during this period.

**40.112(4)** When a licensee or registrant is required pursuant to 40.97(136C) to report to the Agency any exposure of an individual to sources of radiation, the licensee or the registrant shall also provide the individual a report on the exposure data included therein. Such reports shall be transmitted at a time not later than the transmittal to the Agency.

**40.112(5)** At the request of a worker who is terminating employment with the licensee or registrant in work involving exposure to radiation or radioactive material, during the current year, each licensee or registrant shall provide at termination to each such worker, or to the worker's designee, a written report regarding the radiation dose received by that worker from operations of the licensee or registrant during the current year or fraction thereof. If the most recent individual monitoring results are not available at that time, a written estimate of the dose shall be provided together with a clear indication that this is an estimate.

**641—40.113(136C) Presence of representatives of licensees or registrants and workers during inspection.**

**40.113(1)** Each licensee or registrant shall afford to the Agency at all reasonable times opportunity to inspect materials, machines, activities, facilities, premises, and records pursuant to these rules.

**40.113(2)** During an inspection, Agency inspectors may consult privately with workers as specified in 40.114(136C). The licensee or registrant may accompany Agency inspectors during other phases of an inspection.

**40.113(3)** If, at the time of inspection, an individual has been authorized by the workers to represent them during Agency inspections, the licensee or registrant shall notify the inspectors of such authorization and shall give the workers' representative an opportunity to accompany the inspectors during the inspection of physical working conditions.

**40.113(4)** Each worker's representative shall be routinely engaged in work under control of the licensee or registrant and shall have received instructions as specified in 40.111(136C).

**40.113(5)** Different representatives of licensees or registrants and workers may accompany the inspectors during different phases of an inspection if there is no resulting interference with the conduct of the inspection. However, only one worker's representative at a time may accompany the inspectors.

**40.113(6)** With the approval of the licensee or registrant and the workers' representative, an individual who is not routinely engaged in work under control of the licensee or registrant, for example, a consultant to the licensee or registrant or to the workers' representative, shall be afforded the opportunity to accompany Agency inspectors during the inspection of physical working conditions.

**40.113(7)** Notwithstanding the other provisions of 40.113(136C), Agency inspectors are authorized to refuse to permit accompaniment by any individual who deliberately interferes with a fair and orderly inspection. With regard to areas containing information classified by an agency of the U.S. Government in the interest of national security, an individual who accompanies an inspector may have access to such information only if authorized to do so. With regard to any area containing proprietary information, the workers' representative for that area shall be an individual previously authorized by the licensee or registrant to enter that area.

**641—40.114(136C) Consultation with workers during inspections.**

**40.114(1)** Agency inspectors may consult privately with workers concerning matters of occupational radiation protection and other matters related to applicable provisions of these rules and licenses to the extent the inspectors deem necessary for the conduct of an effective and thorough inspection.

**40.114(2)** During the course of an inspection, any worker may bring privately to the attention of the inspectors, either orally or in writing, any past or present condition which the worker has reason to believe may have contributed to or caused any violation of the Act, these rules, or license condition, or any unnecessary exposure of an individual to sources of radiation under the licensee's or registrant's control. Any such notice in writing shall comply with the requirements of 40.115(1).

**40.114(3)** The provisions of 40.114(2) shall not be interpreted as authorization to disregard instructions pursuant to 40.111(136C).

**641—40.115(136C) Requests by workers for inspections.**

**40.115(1)** Any worker or representative of workers believing that a violation of the Act, these rules, or license conditions exists or has occurred in work under a license or registration with regard to radiological working conditions in which the worker is engaged may request an inspection by giving notice of the alleged violation to the Bureau of Radiological Health, Iowa Department of Public Health, Lucas State Office Building, Des Moines, Iowa 50319-0075. Any such notice shall be in writing, shall set forth the specific grounds for the notice, and shall be signed by the worker or representative of the workers. A copy shall be provided to the licensee or registrant by the Bureau of Radiological Health, no later than at the time of inspection except that, upon the request of the worker giving such notice, such worker's name and the name of individuals referred to therein shall not appear in such copy or on any record published, released, or made available by the Agency, except for good cause shown.

**40.115(2)** If, upon receipt of such notice, the Bureau of Radiological Health determines that the complaint meets the requirements set forth in 40.116(1), and that there are reasonable grounds to believe that the alleged violation exists or has occurred, an inspection shall be made as soon as practicable to determine if such alleged violation exists or has occurred. Inspections pursuant to 40.116(136C) need not be limited to matters referred to in the complaint.

**40.115(3)** No licensee, registrant, or contractor or subcontractor of a licensee or registrant shall discharge or in any manner discriminate against any worker because such worker has filed any complaint or instituted or caused to be instituted any proceeding under these rules or has testified or is about to testify in any such proceeding or because of the exercise by such worker on behalf of such worker or others of any option afforded by this chapter.

**641—40.116(136C) Inspections not warranted—informal review.**

**40.116(1) a.** If the Bureau of Radiological Health determines, with respect to a complaint under this rule, that an inspection is not warranted because there are no reasonable grounds to believe that

a violation exists or has occurred, the Bureau of Radiological Health shall notify the complainant in writing of such determination. The complainant may obtain review of such determination by submitting a written statement of position with the Attorney General's Office. Such Agency will provide the licensee or registrant with a copy of such statement by certified mail, excluding, at the request of the complainant, the name of the complainant. The licensee or registrant may submit an opposing written statement of position with the Attorney General's Office. Such Agency will provide the complainant with a copy of such statement by certified mail.

b. Upon the request of the complainant, the Attorney General's Office may hold an informal conference in which the complainant and the licensee or registrant may orally present their views. An informal conference may also be held at the request of the licensee or registrant, but disclosure of the identity of the complainant will be made only following receipt of written authorization from the complainant. After considering all written and oral views presented, the Attorney General's Office shall affirm, modify, or reverse the determination of the Radiation Control Program and furnish the complainant and the licensee or registrant a written notification of the decision and the reason therefor.

**40.116(2)** If the Bureau of Radiological Health determines that an inspection is not warranted because the requirements of 40.116(1) have not been met, the complainant shall be notified in writing of such determination. Such determination shall be without prejudice to the filing of a new complaint meeting the requirements of 40.116(1).

#### **641—40.117(136C) Employee protection.**

**40.117(1)** Discrimination by a licensee or registrant, an applicant for a license or registration, or a contractor or subcontractor of a licensee or applicant against an employee for engaging in certain protected activities is prohibited. Discrimination includes discharge and other actions that relate to compensation, terms, conditions, or privileges of employment. The protected activities are established in 641—Chapters 38 to 45 and in general are related to the administration or enforcement of requirements imposed under 641—Chapters 38 to 45.

a. The protected activities include but are not limited to:

(1) Providing the agency or the individual's employer information about alleged violations of either of the statutes named in this rule or possible violations of requirements imposed under either of those statutes;

(2) Refusing to engage in any practice made unlawful under either of the statutes named in this rule or under these requirements if the employee has identified the alleged illegality to the employer;

(3) Requesting that the agency institute action against the individual's employer for the administration or enforcement of these requirements;

(4) Testifying in any agency proceeding, or before Congress, or at any federal or state proceeding regarding any provision (or proposed provision) of federal statutes or these rules;

(5) Assisting or participating in, or about to assist or participate in, these activities.

b. These activities are protected even if no formal proceeding is actually initiated as a result of the employee's assistance or participation.

c. This rule has no application to any employee alleging discrimination prohibited by this rule who, acting without direction from the individual's employer (or the employer's agent), deliberately causes a violation of any requirement of 641—Chapters 38 to 45.

**40.117(2)** Any employee who believes that the employee has been discharged or otherwise discriminated against by any person for engaging in protected activities specified in 40.117(1)“a” may seek a remedy for the discharge or discrimination through an administrative proceeding in the U.S. Department of Labor. The administrative proceeding must be initiated within 180 days after an alleged violation occurs. The employee may file for the administrative proceeding by filing a complaint alleging the violation with the Department of Labor, Employment Standards Administration, Wage and Hour Division. The Department of Labor may order reinstatement, back pay, and compensatory damages.

**40.117(3)** A violation of 40.117(1)“a”(1) or 40.117(1)“a”(4) by a licensee or registrant, an applicant for a license or registration, or a contractor or subcontractor of a licensee or applicant may be grounds for:

- a.* Denial, revocation, or suspension of the license or registration.
- b.* Imposition of a civil penalty on the licensee, registrant, or applicant.
- c.* Other enforcement action.

**40.117(4)** Actions taken by an employer or others which adversely affect an employee may be predicated upon nondiscriminatory grounds. The prohibition applies when the adverse action occurs because the employee has engaged in protected activities. An employee's engagement in protected activities does not automatically render the employee immune from discharge or discipline for legitimate reasons or from adverse action dictated by nonprohibited considerations.

**40.117(5)** No agreement affecting the compensation, terms, conditions, or privileges of employment, including an agreement to settle a complaint filed by an employee with the Department of Labor pursuant to 641—Chapters 38 to 45, may contain any provision which would prohibit, restrict, or otherwise discourage an employee from participating in protected activity as defined in 40.117(1) "a" including, but not limited to, providing information to the agency or to the individual's employer on potential violations or other matters within the agency's regulatory responsibilities.



## CHAPTER 40

## APPENDIX A

PROTECTION FACTORS FOR RESPIRATORS<sup>a</sup>

	Operating Mode	Assigned Protection Factor
I. Air-Purifying Respirators (particulate 1A <sup>b</sup> only) 1A <sup>c</sup> :		
Filtering facepiece disposable <sup>d</sup>	Negative Pressure	( <sup>d</sup> )
Facepiece, half <sup>e</sup>	Negative Pressure	10
Facepiece, full	Negative Pressure	100
Facepiece, half	Powered air-purifying respirators	50
Facepiece, full	Powered air-purifying respirators	1000
Helmet/hood	Powered air-purifying respirators	1000
Facepiece, loose-fitting	Powered air-purifying respirators	25
II. Atmosphere-Supplying Respirators (particulate, gases and vapors 1A <sup>f</sup> ):		
1. Air-line respirator:		
Facepiece, half	Demand	10
Facepiece, half	Continuous Flow	50
Facepiece, half	Pressure Demand	50
Facepiece, full	Demand	100
Facepiece, full	Continuous Flow	1000
Facepiece, full	Pressure Demand	1000
Helmet/hood	Continuous Flow	1000
Facepiece, loose-fitting	Continuous Flow	25
Suit	Continuous Flow	( <sup>g</sup> )
2. Self-contained breathing apparatus (SCBA):		
Facepiece, full	Demand	<sup>h</sup> 100
Facepiece, full	Pressure Demand	<sup>i</sup> 10,000
Facepiece, full	Demand, Recirculating	<sup>h</sup> 100
Facepiece, full	Positive Pressure Recirculating	<sup>i</sup> 10,000
III. Combination Respirators:		
Any combination of air-purifying and atmosphere-supplying respirators	(1) Assigned protection factor for type and mode of operation as listed above	

<sup>a</sup>These assigned protection factors apply only in a respiratory protection program that meets the requirement of 641—Chapter 40. They are applicable only to airborne radiological hazards and may not be appropriate to circumstances when chemical or other respiratory hazards exist instead of, or in addition to, radioactive hazards. Selection and use of respirators for such circumstances must also comply with Department of Labor regulations.

Radioactive contaminants for which the concentration values in Table I, Column 3, of Appendix B to 641—Chapter 40 are based on internal dose due to inhalation may, in addition, present external exposure

hazards at higher concentrations. Under these circumstances, limitations on occupancy may have to be governed by external dose limits.

<sup>b</sup>Air-purifying respirators with  $APF < 100$  must be equipped with particulate filters that are at least 95 percent efficient. Air-purifying respirators with  $APF = 100$  must be equipped with particulate filters that are at least 99 percent efficient. Air-purifying respirators with  $APF > 100$  must be equipped with particulate filters that are at least 99.97 percent efficient.

<sup>c</sup>The licensee may apply to the agency for the use of an APF greater than 1 for sorbent cartridges as protection against airborne radioactive gases and vapors (e.g., radioiodine).

<sup>d</sup>Licensees may permit individuals to use this type of respirator who have not been medically screened or fit tested on the device provided that no credit be taken for the use in estimating intake or dose. It is also recognized that it is difficult to perform an effective positive or negative pressure pre-use user seal check on this type of device. All other respiratory protection program requirements listed in 641—40.50(136C) apply. An assigned protection factor has not been assigned for these devices. However, an APF equal to 10 may be used if the licensee can demonstrate a fit factor of at least 100 by use of a validated or evaluated, qualitative or quantitative fit test.

<sup>e</sup>Under-chin type only. No distinction is made in this Appendix between elastomeric half-masks with replaceable cartridges and those designed with the filter medium as an integral part of the facepiece (e.g., disposable or reusable disposable). Both types are acceptable so long as the seal area of the latter contains some substantial type of seal-enhancing material such as rubber or plastic, the two or more suspension straps are adjustable, the filter medium is at least 95 percent efficient, and all other requirements of 641—Chapter 40 are met.

<sup>f</sup>The assigned protection factors for gases and vapors are not applicable to radioactive contaminants that present an absorption or submersion hazard. For tritium oxide vapor, approximately one-third of the intake occurs by absorption through the skin so that an overall protection factor of 3 is appropriate when atmosphere-supplying respirators are used to protect against tritium oxide. Exposure to radioactive noble gases is not considered a significant respiratory hazard, and protective actions for these contaminants should be based on external (submersion) dose considerations.

<sup>g</sup>No NIOSH approval schedule is currently available for atmosphere-supplying suits. This equipment may be used in an acceptable respiratory protection program as long as all the other minimum program requirements, with the exception of fit testing, are met.

<sup>h</sup>The licensee should implement institutional controls to ensure that these devices are not used in areas immediately dangerous to life or health.

<sup>i</sup>This type of respirator may be used as an emergency device in unknown concentrations for protection against inhalation hazards. External radiation hazards and other limitations to permitted exposure such as skin absorption shall be taken into account in these circumstances. This device may not be used by any individual who experiences perceptible outward leakage of breathing gas while wearing the device.

## CHAPTER 40

## APPENDIX B

ANNUAL LIMITS ON INTAKE (ALI) AND DERIVED AIR CONCENTRATIONS  
(DAC) OF RADIONUCLIDES FOR OCCUPATIONAL EXPOSURE; EFFLUENT  
CONCENTRATIONS; CONCENTRATIONS FOR RELEASE TO SANITARY SEWERAGE

## Introduction

For each radionuclide, Table I indicates the chemical form which is to be used for selecting the appropriate ALI or DAC value. The ALIs and DACs for inhalation are given for an aerosol with an activity median aerodynamic diameter (AMAD) of 1  $\mu\text{m}$ , micron, and for three classes (D,W,Y) of radioactive material, which refer to their retention (approximately days, weeks or years) in the pulmonary region of the lung. This classification applies to a range of clearance half-times for D if less than 10 days, for W from 10 to 100 days, and for Y greater than 100 days. Table II provides concentration limits for airborne and liquid effluents released to the general environment. Table III provides concentration limits for discharges to sanitary sewerage.

NOTE: The values in Tables I, II, and III are presented in the computer "E" notation. In this notation a value of 6E-02 represents a value of  $6 \times 10^{-2}$  or 0.06, 6E+2 represents  $6 \times 10^2$  or 600, and 6E+0 represents  $6 \times 10^0$  or 6.

TABLE I "OCCUPATIONAL VALUES"

Note that the columns in Table I of this appendix captioned "Oral Ingestion ALI," "Inhalation ALI," and "DAC," are applicable to occupational exposure to radioactive material.

The ALIs in this appendix are the annual intakes of given radionuclide by "Reference Person" which would result in either (1) a committed effective dose equivalent of 5 rem (0.05 Sv), stochastic ALI, or (2) a committed dose equivalent of 50 rem (0.5 Sv) to an organ or tissue, nonstochastic ALI. The stochastic ALIs were derived to result in a risk, due to irradiation of organs and tissues, comparable to the risk associated with deep dose equivalent to the whole body of 5 rem (0.05 Sv). The derivation includes multiplying the committed dose equivalent to an organ or tissue by a weighting factor,  $w_T$ . This weighting factor is the proportion of the risk of stochastic effects resulting from irradiation of the organ or tissue, T, to the total risk of stochastic effects when the whole body is irradiated uniformly. The values of  $w_T$  are listed under the definition of weighting factor in 40.2. The nonstochastic ALIs were derived to avoid nonstochastic effects, such as prompt damage to tissue or reduction in organ function.

A value of  $w_T = 0.06$  is applicable to each of the five organs or tissues in the "remainder" category receiving the highest dose equivalents, and the dose equivalents of all other remaining tissues may be disregarded. The following portions of the GI tract—stomach, small intestine, upper large intestine, and lower large intestine—are to be treated as four separate organs.

The air concentration values listed in Table II, Column 1 were derived by one of two methods. For those radionuclides for which the stochastic limit is governing, the occupational stochastic inhalation ALI was divided by  $2.4 \times 10^9$  (ml), relating the inhalation ALI to the DAC, as explained above, and then divided by a factor of 300. The factor of 300 includes the following components: a factor of 50 to relate the 5 rem (0.05 Sv) annual occupational dose limit to the 0.1 rem limit for members of the public, a factor of 3 to adjust for the difference in exposure time and the inhalation rate for a worker and that for members of the public; and a factor of 2 to adjust the occupational values, derived for adults, so that they are applicable to other age groups.

When an ALI is defined by the stochastic dose limit, this value alone is given. When an ALI is determined by the nonstochastic dose limit to an organ, the organ or tissue to which the limit applies is shown, and the ALI for the stochastic limit is shown in parentheses. Abbreviated organ or tissue designations are used:

LLI wall	=	lower large intestine wall;
St. wall	=	stomach wall;
Blad wall	=	bladder wall; and
Bone surf	=	bone surface.

The use of the ALIs listed first, the more limiting of the stochastic and nonstochastic ALIs, will ensure that nonstochastic effects are avoided and that the risk of stochastic effects is limited to an acceptably low value. If, in a particular situation involving a radionuclide for which the nonstochastic ALI is limiting, use of that nonstochastic ALI is considered unduly conservative, the licensee may use the stochastic ALI to determine the committed effective dose equivalent. However, the licensee shall also ensure that the 50 rem (0.5 Sv) dose equivalent limit for any organ or tissue is not exceeded by the sum of the external deep dose equivalent plus the internal committed dose equivalent to that organ, not the effective dose. For the case where there is no external dose contribution, this would be demonstrated if the sum of the fractions of the nonstochastic ALIs ( $ALI_{ns}$ ) that contribute to the committed dose equivalent to the organ receiving the highest dose does not exceed unity, that is,  $\Sigma$  (intake (in  $\mu\text{Ci}$ ) of each radionuclide/ $ALI_{ns}$ )  $\leq 1.0$ . If there is an external deep dose equivalent contribution of  $H_d$ , then this sum must be less than  $1 - (H_d/50)$ , instead of  $\leq 1.0$ .

Note that the dose equivalents for an extremity, skin, and lens of the eye are not considered in computing the committed effective dose equivalent, but are subject to limits that must be met separately.

The derived air concentration (DAC) values are derived limits intended to control chronic occupational exposures. The relationship between the DAC and the ALI is given by:

$DAC = ALI(\text{in } \mu\text{Ci}) / (2000 \text{ hours per working year} \times 60 \text{ minutes/hour} \times 2 \times 10^4 \text{ ml per minute}) = [ALI / 2.4 \times 10^9] \mu\text{Ci/ml}$ , where  $2 \times 10^4$  ml is the volume of air breathed per minute at work by Reference Person under working conditions of light work.

The DAC values relate to one of two modes of exposure: either external submersion or the internal committed dose equivalents resulting from inhalation of radioactive materials. DACs based upon submersion are for immersion in a semi-infinite cloud of uniform concentration and apply to each radionuclide separately.

The ALI and DAC values include contributions to exposure by the single radionuclide named and any in-growth of daughter radionuclides produced in the body by decay of the parent. However, intakes that include both the parent and daughter radionuclides should be treated by the general method appropriate for mixtures.

The values of ALI and DAC do not apply directly when the individual both ingests and inhales a radionuclide, when the individual is exposed to a mixture of radionuclides by either inhalation or ingestion or both, or when the individual is exposed to both internal and external irradiation. See 641—40.16(136C). When an individual is exposed to radioactive materials which fall under several of the translocation classifications of the same radionuclide, such as, Class D, Class W, or Class Y, the exposure may be evaluated as if it were a mixture of different radionuclides.

It should be noted that the classification of a compound as Class D, W, or Y is based on the chemical form of the compound and does not take into account the radiological half-life of different radionuclides. For this reason, values are given for Class D, W, and Y compounds, even for very short-lived radionuclides.

TABLE II "EFFLUENT CONCENTRATIONS"

The columns in Table II of this appendix captioned "Effluents," "Air" and "Water" are applicable to the assessment and control of dose to the public, particularly in the implementation of the provisions of 641—40.27(136C). The concentration values given in Columns 1 and 2 of Table II are equivalent to the radionuclide concentrations which, if inhaled or ingested continuously over the course of a year, would produce a total effective dose equivalent of 0.05 rem (0.5 mSv).

Consideration of nonstochastic limits has not been included in deriving the air and water effluent concentration limits because nonstochastic effects are presumed not to occur at or below the dose levels

established for individual members of the public. For radionuclides, where the nonstochastic limit was governing in deriving the occupational DAC, the stochastic ALI was used in deriving the corresponding airborne effluent limit in Table II. For this reason, the DAC and airborne effluent limits are not always proportional as they were in Appendix A of this chapter of the eighth edition of Volume I of the Suggested State Regulations for Control of Radiation.

The air concentration values listed in Table II, Column 1 were derived by one of two methods. For those radionuclides for which the stochastic limit is governing, the occupational stochastic inhalation ALI was divided by  $2.4 \times 10^9$  (ml), relating the inhalation ALI to the DAC, as explained above, and then divided by a factor of 300. The factor of 300 includes the following components: a factor of 50 to relate the 5 rem (0.05 Sv) annual occupational dose limit to the 0.1 rem limit for members of the public, a factor of 3 to adjust for the difference in exposure time and the inhalation rate for a worker and that for members of the public; and a factor of 2 to adjust the occupational values, derived for adults, so that they are applicable to other age groups.

For those radionuclides for which submersion, that is external dose, is limiting, the occupational DAC in Table I, Column 3 was divided by 219. The factor of 219 is composed of a factor of 50, as described above, and a factor of 4.38 relating occupational exposure for 2,000 hours per year to full-time exposure (8,760 hours per year). Note that an additional factor of 2 for age considerations is not warranted in the submersion case.

The water concentrations were derived by taking the most restrictive occupational stochastic oral ingestion ALI and dividing by  $7.3 \times 10^7$ . The factor of  $7.3 \times 10^7$  (ml) includes the following components: the factors of 50 and 2 described above and a factor of  $7.3 \times 10^5$  (ml) which is the annual water intake of Reference Person.

Note 2 of this appendix provides groupings of radionuclides which are applicable to unknown mixtures of radionuclides. These groupings, including occupational inhalation ALIs and DACs, air and water effluent concentrations and releases to sewer, require demonstrating that the most limiting radionuclides in successive classes are absent. The limit for the unknown mixture is defined when the presence of one of the listed radionuclides cannot be definitely excluded as being present either from knowledge of the radionuclide composition of the source or from actual measurements.

TABLE III "RELEASES TO SEWERS"

The monthly average concentrations for release to sanitary sewerage are applicable to the provisions in 40.72. The concentration values were derived by taking the most restrictive occupational stochastic oral ingestion ALI and dividing by  $7.3 \times 10^6$  (ml). The factor of  $7.3 \times 10^6$  (ml) is composed of a factor of  $7.3 \times 10^5$  (ml), the annual water intake by Reference Person, and a factor of 10, such that the concentrations, if the sewage released by the licensee were the only source of water ingested by a Reference Person during a year, would result in a committed effective dose equivalent of 0.5 rem.

#### LIST OF ELEMENTS

Atomic			Atomic		
<u>Name</u>	<u>Symbol</u>	<u>Number</u>	<u>Name</u>	<u>Symbol</u>	<u>Number</u>
Actinium	Ac	89	Mercury	Hg	80
Aluminum	Al	13	Molybdenum	Mo	42
Americium	Am	95	Neodymium	Nd	60
Antimony	Sb	51	Neptunium	Np	93
Argon	Ar	18	Nickel	Ni	28
Arsenic	As	33	Niobium	Nb	41
Astatine	At	85	Osmium	Os	76
Barium	Ba	56	Palladium	Pd	46
Berkelium	Bk	97	Phosphorus	P	15
Beryllium	Be	4	Platinum	Pt	78
Bismuth	Bi	83	Plutonium	Pu	94

Bromine	Br	35	Polonium	Po	84
Cadmium	Cd	48	Potassium	K	19
Calcium	Ca	20	Praseodymium	Pr	59
Californium	Cf	98	Promethium	Pm	61
Carbon	C	6	Protactinium	Pa	91
Cerium	Ce	58	Radium	Ra	88
Cesium	Cs	55	Radon	Rn	86
Chlorine	Cl	17	Rhenium	Re	75
Chromium	Cr	24	Rhodium	Rh	45
Cobalt	Co	27	Rubidium	Rb	37
Copper	Cu	29	Ruthenium	Ru	44
Curium	Cm	96	Samarium	Sm	62
Dysprosium	Dy	66	Scandium	Sc	21
Einsteinium	Es	99	Selenium	Se	34
Erbium	Er	68	Silicon	Si	14
Europium	Eu	63	Silver	Ag	47
Fermium	Fm	100	Sodium	Na	11
Fluorine	F	9	Strontium	Sr	38
Francium	Fr	87	Sulfur	S	16
Gadolinium	Gd	64	Tantalum	Ta	73
Gallium	Ga	31	Technetium	Tc	43
Germanium	Ge	32	Tellurium	Te	52
Gold	Au	79	Terbium	Tb	65
Hafnium	Hf	72	Thallium	Tl	81
Holmium	Ho	67	Thorium	Th	90
Hydrogen	H	1	Thulium	Tm	69
Indium	In	49	Tin	Sn	50
Iodine	I	53	Titanium	Ti	22
Iridium	Ir	77	Tungsten	W	74
Iron	Fe	26	Uranium	U	92
Krypton	Kr	36	Vanadium	V	23
Lanthanum	La	57	Xenon	Xe	54
Lead	Pb	82	Ytterbium	Yb	70
Lutetium	Lu	71	Yttrium	Y	39
Magnesium	Mg	12	Zinc	Zn	30
Manganese	Mn	25	Zirconium	Zr	40
Mendelevium	Md	101			

Atomic Radio-nuclide No.	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers	
		Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	Monthly Average Concentration ( $\mu\text{Ci/ml}$ )	
		Oral Ingestion	INHALATION		Air ( $\mu\text{Ci/ml}$ )	Water ( $\mu\text{Ci/ml}$ )		
		ALI ( $\mu\text{Ci}$ )	ALI ( $\mu\text{Ci}$ )	DAC ( $\mu\text{Ci/ml}$ )				
1	Hydrogen-3	Water, DAC includes skin absorption	8E+4	8E+4	2E-5	1E-7	1E-3	1E-2
		Gas (HT or T <sub>2</sub> ) Submersion <sup>1</sup> : Use above values as HT and T <sub>2</sub> oxidize in air and in the body to HTO.						
4	Beryllium-7	W, all compounds except those given for Y	4E+4	2E+4	9E-6	3E-8	6E-4	6E-3
		Y, oxides, halides, and nitrates	-	2E+4	8E-6	3E-8	-	-
4	Beryllium-10	W, see <sup>7</sup> Be	1E+3 LLI wall	2E+2	6E-8	2E-10	-	-
			(1E+3)	-	-	-	2E-5	2E-4
		Y, see <sup>7</sup> Be	-	1E+1	6E-9	2E-11	-	-
6	Carbon-11 <sup>2</sup>	Monoxide	-	1E+6	5E-4	2E-6	-	-
		Dioxide	-	6E+5	3E-4	9E-7	-	-
		Compounds	4E+5	4E+5	2E-4	6E-7	6E-3	6E-2
6	Carbon-14	Monoxide	-	2E+6	7E-4	2E-6	-	-
		Dioxide	-	2E+5	9E-5	3E-7	-	-
		Compounds	2E+3	2E+3	1E-6	3E-9	3E-5	3E-4
9	Fluorine-18 <sup>2</sup>	D, fluorides of H, Li, Na, K, Rb, Cs, and Fr	5E+4	7E+4	3E-5	1E-7	-	-
			St wall					
			(5E+4)	-	-	-	7E-4	7E-3
		W, fluorides of Be, Mg, Ca, Sr, Ba, Ra, Al, Ga, In, Tl, As, Sb, Bi, Fe, Ru, Os, Co, Ni, Pd, Pt, Cu, Ag, Au, Zn, Cd, Hg, Sc, Y, Ti, Zr, V, Nb, Ta, Mn, Tc, and Re		9E+4	4E-5	1E-7	-	-
		Y, lanthanum fluoride	-	8E+4	3E-5	1E-7	-	-
11	Sodium-22	D, all compounds	4E+2	6E+2	3E-7	9E-10	6E-6	6E-5
11	Sodium-24	D, all compounds	4E+3	5E+3	2E-6	7E-9	5E-5	5E-4
12	Magnesium-28	D, all compounds except those given for W	7E+2	2E+3	7E-7	2E-9	9E-6	9E-5
		W, oxides, hydroxides, carbides, halides, and nitrates	-	1E+3	5E-7	2E-9	-	-
13	Aluminum-26	D, all compounds except those given for W	4E+2	6E+1	3E-8	9E-11	6E-6	6E-5
		W, oxides, hydroxides, carbides, halides, and nitrates	-	9E+1	4E-8	1E-10	-	-

Atomic Radio-nuclide No.	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
		Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	Monthly Average Concentration (μCi/ml)
		Oral Ingestion ALI (μCi)	INHALATION		Air (μCi/ml)	Water (μCi/ml)	
			ALI (μCi)	DAC (μCi/ml)			
14 Silicon-31	D, all compounds except those given for W and Y	9E+3	3E+4	1E-5	4E-8	1E-4	1E-3
	W, oxides, hydroxides, carbides, and nitrates	-	3E+4	1E-5	5E-8	-	-
	Y, aluminosilicate glass	-	3E+4	1E-5	4E-8	-	-
14 Silicon-32	D, see <sup>31</sup> Si	2E+3	2E+2	1E-7	3E-10	-	-
	LLI wall	(3E+3)	-	-	-	4E-5	4E-4
	W, see <sup>31</sup> Si	-	1E+2	5E-8	2E-10	-	-
15 Phosphorus-32	D, all compounds except phosphates given for W	6E+2	9E+2	4E-7	1E-9	9E-6	9E-5
	W, phosphates of Zn <sup>2+</sup> , S <sup>3+</sup> , Mg <sup>2+</sup> , Fe <sup>3+</sup> , Bi <sup>3+</sup> , and lanthanides	-	4E+2	2E-7	5E-10	-	-
	Y, see <sup>31</sup> Si	-	5E+0	2E-9	7E-12	-	-
15 Phosphorus-33	D, see <sup>32</sup> P	6E+3	8E+3	4E-6	1E-8	8E-5	8E-4
	W, see <sup>32</sup> P	-	3E+3	1E-6	4E-9	-	-
16 Sulfur-35	Vapor	1E+4	6E-6	2E-8	-	-	-
	D, sulfides and sulfates except those given for W	1E+4	2E+4	7E-6	2E-8	-	-
	LLI wall	(8E+3)	-	-	-	1E-4	1E-3
	W, elemental sulfur, sulfides of Sr, Ba, Ge, Sn, Pb, As, Sb, Bi, Cu, Ag, Au, Zn, Cd, Hg, W, and Mo. Sulfates of Ca, Sr, Ba, Ra, As, Sb, and Bi	6E+3	2E+3	9E-7	3E-9	-	-
17 Chlorine-36	D, chlorides of H, Li, Na, K, Rb, Cs, and Fr	2E+3	2E+3	1E-6	3E-9	2E-5	2E-4
	W, chlorides of lanthanides, Be, Mg, Ca, Sr, Ba, Ra, Al, Ga, In, Tl, Ge, Sn, Pb, As, Sb, Bi, Fe, Ru, Os, Co, Rh, Ir, Ni, Pd, Pt, Cu, Ag, Au, Zn, Cd, Hg, Sc, Y, Ti, Zr, Hf, V, Nb, Ta, Cr, Mo, W, Mn, Tc, and Re	-	2E+2	1E-7	3E-10	-	-



Atomic Radio-nuclide No.	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers	
		Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	Monthly Average Concentration (μCi/ml)	
		Oral Ingestion	INHALATION		Air (μCi/ml)	Water (μCi/ml)		
		ALI (μCi)	ALI (μCi)	DAC (μCi/ml)				
17	Chlorine-38 <sup>2</sup>	D, see <sup>36</sup> Cl	2E+4	4E+4	2E-5	6E-8	-	-
		St wall	(3E+4)	-	-	-	3E-4	3E-3
		W, see <sup>36</sup> Cl	-	5E+4	2E-5	6E-8	-	-
17	Chlorine-39 <sup>2</sup>	D, see <sup>36</sup> Cl	2E+4	5E+4	2E-5	7E-8	-	-
		St wall	(4E+4)	-	-	-	5E-4	5E-3
		W, see <sup>36</sup> Cl	-	6E+4	2E-5	8E-8	-	-
18	Argon-37	Submersion <sup>1</sup>	-	-	1E+0	6E-3	-	-
18	Argon-39	Submersion <sup>1</sup>	-	-	2E-4	8E-7	-	-
18	Argon-41	Submersion <sup>1</sup>	-	-	3E-6	1E-8	-	-
19	Potassium-40	D, all compounds	3E+2	4E+2	2E-7	6E-10	4E-6	4E-5
19	Potassium-42	D, all compounds	5E+3	5E+3	2E-6	7E-9	6E-5	6E-4
19	Potassium-43	D, all compounds	6E+3	9E+3	4E-6	1E-8	9E-5	9E-4
19	Potassium-44 <sup>2</sup>	D, all compounds	2E+4	7E+4	3E-5	9E-8	-	-
		St wall	(4E+4)	-	-	-	5E-4	5E-3
19	Potassium-45 <sup>2</sup>	D, all compounds	3E+4	1E+5	5E-5	2E-7	-	-
		St wall	(5E+4)	-	-	-	7E-4	7E-3
20	Calcium-41	W, all compounds	3E+3	4E+3	2E-6	-	-	-
		Bone surf	(4E+3)	(4E+3)	-	5E-9	6E-5	6E-4
20	Calcium-45	W, all compounds	2E+3	8E+2	4E-7	1E-9	2E-5	2E-4
20	Calcium-47	W, all compounds	8E+2	9E+2	4E-7	1E-9	1E-5	1E-4
21	Scandium-43	Y, all compounds	7E+3	2E+4	9E-6	3E-8	1E-4	1E-3
21	Scandium-44m	Y, all compounds	5E+2	7E+2	3E-7	1E-9	7E-6	7E-5
21	Scandium-44	Y, all compounds	4E+3	1E+4	5E-6	2E-8	5E-5	5E-4
21	Scandium-46	Y, all compounds	9E+2	2E+2	1E-7	3E-10	1E-5	1E-4
21	Scandium-47	Y, all compounds	2E+3	3E+3	1E-6	4E-9	-	-
		LLI wall	(3E+3)	-	-	-	4E-5	4E-4
21	Scandium-48	Y, all compounds	8E+2	1E+3	6E-7	2E-9	1E-5	1E-4
21	Scandium-49 <sup>2</sup>	Y, all compounds	2E+4	5E+4	2E-5	8E-8	3E-4	3E-3
22	Titanium-44	D, all compounds except those given for W and Y	3E+2	1E+1	5E-9	2E-11	4E-6	4E-5
		W, oxides, hydroxides, carbides, halides, and nitrates	-	3E+1	1E-8	4E-11	-	-
		Y, SrTiO	-	6E+0	2E-9	8E-12	-	-

Atomic Radio-nuclide No.	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
		Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	Monthly Average Concentration (μCi/ml)
		Oral Ingestion	INHALATION		Air (μCi/ml)	Water (μCi/ml)	
			ALI (μCi)	ALI (μCi)			
22 Titanium-45	D, see <sup>44</sup> Ti	9E+3	3E+4	1E-5	3E-8	1E-4	1E-3
	W, see <sup>44</sup> Ti	-	4E+4	1E-5	5E-8	-	-
	Y, see <sup>44</sup> Ti	-	3E+4	1E-5	4E-8	-	-
23 Vanadium-47 <sup>2</sup>	D, all compounds except those given for W	3E+4	8E+4	3E-5	1E-7	-	-
	St wall	(3E+4)	-	-	-	4E-4	4E-3
23 Vanadium-48	W, oxides, hydroxides, carbides, and halides	-	1E+5	4E-5	1E-7	-	-
	D, see <sup>47</sup> V	6E+2	1E+3	5E-7	2E-9	9E-6	9E-5
23 Vanadium-49	W, see <sup>47</sup> V	-	6E+2	3E-7	9E-10	-	-
	D, see <sup>47</sup> V	7E+4	3E+4	1E-5	-	-	-
24 Chromium-48	LLI wall	(9E+4)	(3E+4)	-	5E-8	1E-3	1E-2
	Bone surf	-	2E+4	8E-6	2E-8	-	-
	W, see <sup>47</sup> V	-	2E+4	8E-6	2E-8	-	-
24 Chromium-49 <sup>2</sup>	D, all compounds except those given for W and Y	6E+3	1E+4	5E-6	2E-8	8E-5	8E-4
	W, halides and nitrates	-	7E+3	3E-6	1E-8	-	-
	Y, oxides and hydroxides	-	7E+3	3E-6	1E-8	-	-
24 Chromium-51	D, see <sup>48</sup> Cr	3E+4	8E+4	4E-5	1E-7	4E-4	4E-3
	W, see <sup>48</sup> Cr	-	1E+5	4E-5	1E-7	-	-
	Y, see <sup>48</sup> Cr	-	9E+4	4E-5	1E-7	-	-
25 Manganese-51 <sup>2</sup>	D, see <sup>48</sup> Cr	4E+4	5E+4	2E-5	6E-8	5E-4	5E-3
	W, see <sup>48</sup> Cr	-	2E+4	1E-5	3E-8	-	-
	Y, see <sup>48</sup> Cr	-	2E+4	8E-6	3E-8	-	-
25 Manganese-52 <sup>m2</sup>	D, all compounds except those given for W	2E+4	5E+4	2E-5	7E-8	3E-4	3E-3
	W, oxides, hydroxides, halides, and nitrates	-	6E+4	3E-5	8E-8	-	-
25 Manganese-52	D, see <sup>51</sup> Mn	3E+4	9E+4	4E-5	1E-7	-	-
	St wall	(4E+4)	-	-	-	5E-4	5E-3
	W, see <sup>51</sup> Mn	-	1E+5	4E-5	1E-7	-	-
25 Manganese-52	D, see <sup>51</sup> Mn	7E+2	1E+3	5E-7	2E-9	1E-5	1E-4
	W, see <sup>51</sup> Mn	-	9E+2	4E-7	1E-9	-	-

Atomic Radio-nuclide No.	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers	
		Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	Monthly Average Concentration ( $\mu\text{Ci/ml}$ )	
		Oral Ingestion ALI ( $\mu\text{Ci}$ )	INHALATION		Air ( $\mu\text{Ci/ml}$ )	Water ( $\mu\text{Ci/ml}$ )		
			ALI ( $\mu\text{Ci}$ )	DAC ( $\mu\text{Ci/ml}$ )				
25	Manganese-53	D, see $^{51}\text{Mn}$	5E+4	1E+4	5E-6	-	7E-4	7E-3
				Bone surf				
			-	(2E+4)	-	3E-8	-	-
		W, see $^{51}\text{Mn}$	-	1E+4	5E-6	2E-8	-	-
25	Manganese-54	D, see $^{51}\text{Mn}$	2E+3	9E+2	4E-7	1E-9	3E-5	3E-4
		W, see $^{51}\text{Mn}$	-	8E+2	3E-7	1E-9	-	-
25	Manganese-56	D, see $^{51}\text{Mn}$	5E+3	2E+4	6E-6	2E-8	7E-5	7E-4
		W, see $^{51}\text{Mn}$	-	2E+4	9E-6	3E-8	-	-
26	Iron-52	D, all compounds except those given for W	9E+2	3E+3	1E-6	4E-9	1E-5	1E-4
		W, oxides, hydroxides, and halides	-	2E+3	1E-6	3E-9	-	-
26	Iron-55	D, see $^{52}\text{Fe}$	9E+3	2E+3	8E-7	3E-9	1E-4	1E-3
		W, see $^{52}\text{Fe}$	-	4E+3	2E-6	6E-9	-	-
26	Iron-59	D, see $^{52}\text{Fe}$	8E+2	3E+2	1E-7	5E-10	1E-5	1E-4
		W, see $^{52}\text{Fe}$	-	5E+2	2E-7	7E-10	-	-
26	Iron-60	D, see $^{52}\text{Fe}$	3E+1	6E+0	3E-9	9E-12	4E-7	4E-6
		W, see $^{52}\text{Fe}$	-	2E+1	8E-9	3E-11	-	-
27	Cobalt-55	W, all compounds except those given for Y	1E+3	3E+3	1E-6	4E-9	2E-5	2E-4
		Y, oxides, hydroxides, halides, and nitrates	-	3E+3	1E-6	4E-9	-	-
27	Cobalt-56	W, see $^{55}\text{Co}$	5E+2	3E+2	1E-7	4E-10	6E-6	6E-5
		Y, see $^{55}\text{Co}$	4E+2	2E+2	8E-8	3E-10	-	-
27	Cobalt-57	W, see $^{55}\text{Co}$	8E+3	3E+3	1E-6	4E-9	6E-5	6E-4
		Y, see $^{55}\text{Co}$	4E+3	7E+2	3E-7	9E-10	-	-
27	Cobalt-58m	W, see $^{55}\text{Co}$	6E+4	9E+4	4E-5	1E-7	8E-4	8E-3
		Y, see $^{55}\text{Co}$	-	6E+4	3E-5	9E-8	-	-
27	Cobalt-58	W, see $^{55}\text{Co}$	2E+3	1E+3	5E-7	2E-9	2E-5	2E-4
		Y, see $^{55}\text{Co}$	1E+3	7E+2	3E-7	1E-9	-	-
27	Cobalt-60m <sup>2</sup>	W, see $^{55}\text{Co}$	1E+6	4E+6	2E-3	6E-6	-	-
		St wall	(1E+6)	-	-	-	2E-2	2E-1
		Y, see $^{55}\text{Co}$	-	3E+6	1E-3	4E-6	-	-
27	Cobalt-60	W, see $^{55}\text{Co}$	5E+2	2E+2	7E-8	2E-10	3E-6	3E-5
		Y, see $^{55}\text{Co}$	2E+2	3E+1	1E-8	5E-11	-	-
27	Cobalt-61 <sup>2</sup>	W, see $^{55}\text{Co}$	2E+4	6E+4	3E-5	9E-8	3E-4	3E-3
		Y, see $^{55}\text{Co}$	2E+4	6E+4	2E-5	8E-8	-	-

Atomic Radio-nuclide No.	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers	
		Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	Monthly Average Concentration (μCi/ml)	
		Oral Ingestion ALI (μCi)	INHALATION		Air (μCi/ml)	Water (μCi/ml)		
			ALI (μCi)	DAC (μCi/ml)				
27	Cobalt-62m <sup>2</sup>	W, see <sup>55</sup> Co	4E+4	2E+5	7E-5	2E-7	-	-
		St wall	(5E+4)	-	-	-	7E-4	7E-3
		Y, see <sup>55</sup> Co	-	2E+5	6E-5	2E-7	-	-
28	Nickel-56	D, all compounds except those given for W	1E+3	2E+3	8E-7	3E-9	2E-5	2E-4
		W, oxides, hydroxides, and carbides	-	1E+3	5E-7	2E-9	-	-
		Vapor	-	1E+3	5E-7	2E-9	-	-
28	Nickel-57	D, see <sup>56</sup> Ni	2E+3	5E+3	2E-6	7E-9	2E-5	2E-4
		W, see <sup>56</sup> Ni	-	3E+3	1E-6	4E-9	-	-
		Vapor	-	6E+3	3E-6	9E-9	-	-
28	Nickel-59	D, see <sup>56</sup> Ni	2E+4	4E+3	2E-6	5E-9	3E-4	3E-3
		W, see <sup>56</sup> Ni	-	7E+3	3E-6	1E-8	-	-
		Vapor	-	2E+3	8E-7	3E-9	-	-
28	Nickel-63	D, see <sup>56</sup> Ni	9E+3	2E+3	7E-7	2E-9	1E-4	1E-3
		W, see <sup>56</sup> Ni	-	3E+3	1E-6	4E-9	-	-
		Vapor	-	8E+2	3E-7	1E-9	-	-
28	Nickel-65	D, see <sup>56</sup> Ni	8E+3	2E+4	1E-5	3E-8	1E-4	1E-3
		W, see <sup>56</sup> Ni	-	3E+4	1E-5	4E-8	-	-
		Vapor	-	2E+4	7E-6	2E-8	-	-
28	Nickel-66	D, see <sup>56</sup> Ni	4E+2	2E+3	7E-7	2E-9	-	-
		LLI wall	(5E+2)	-	-	-	6E-6	6E-5
		W, see <sup>56</sup> Ni	-	6E+2	3E-7	9E-10	-	-
		Vapor	-	3E+3	1E-6	4E-9	-	-
29	Copper-60 <sup>2</sup>	D, all compounds except those given for W and Y	3E+4	9E+4	4E-5	1E-7	-	-
		St wall	(3E+4)	-	-	-	4E-4	4E-3
		W, sulfides, halides, and nitrates	-	1E+5	5E-5	2E-7	-	-
		Y, oxides and hydroxides	-	1E+5	4E-5	1E-7	-	-
29	Copper-61	D, see <sup>60</sup> Cu	1E+4	3E+4	1E-5	4E-8	2E-4	2E-3
		W, see <sup>60</sup> Cu	-	4E+4	2E-5	6E-8	-	-
		Y, see <sup>60</sup> Cu	-	4E+4	1E-5	5E-8	-	-
29	Copper-64	D, see <sup>60</sup> Cu	1E+4	3E+4	1E-5	4E-8	2E-4	2E-3
		W, see <sup>60</sup> Cu	-	2E+4	1E-5	3E-8	-	-
		Y, see <sup>60</sup> Cu	-	2E+4	9E-6	3E-8	-	-
29	Copper-67	D, see <sup>60</sup> Cu	5E+3	8E+3	3E-6	1E-8	6E-5	6E-4
		W, see <sup>60</sup> Cu	-	5E+3	2E-6	7E-9	-	-
		Y, see <sup>60</sup> Cu	-	5E+3	2E-6	6E-9	-	-

Atomic Radio-nuclide No.	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers	
		Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	Monthly Average Concentration (μCi/ml)	
		Oral Ingestion	INHALATION		Air (μCi/ml)	Water (μCi/ml)		
			ALI (μCi)	ALI (μCi)				DAC (μCi/ml)
30	Zinc-62	Y, all compounds	1E+3	3E+3	1E-6	4E-9	2E-5	2E-4
30	Zinc-63 <sup>2</sup>	Y, all compounds	2E+4	7E+4	3E-5	9E-8	-	-
			St wall					
			(3E+4)	-	-	-	3E-4	3E-3
30	Zinc-65	Y, all compounds	4E+2	3E+2	1E-7	4E-10	5E-6	5E-5
30	Zinc-69m	Y, all compounds	4E+3	7E+3	3E-6	1E-8	6E-5	6E-4
30	Zinc-69 <sup>2</sup>	Y, all compounds	6E+4	1E+5	6E-5	2E-7	8E-4	8E-3
30	Zinc-71m	Y, all compounds	6E+3	2E+4	7E-6	2E-8	8E-5	8E-4
30	Zinc-72	Y, all compounds	1E+3	1E+3	5E-7	2E-9	1E-5	1E-4
31	Gallium-65 <sup>2</sup>	D, all compounds except those given for W	5E+4	2E+5	7E-5	2E-7	-	-
			St wall					
			(6E+4)	-	-	-	9E-4	9E-3
		W, oxides, hydroxides, carbides, halides, and nitrates	-	2E+5	8E-5	3E-7	-	-
31	Gallium-66	D, see <sup>65</sup> Ga	1E+3	4E+3	1E-6	5E-9	1E-5	1E-4
		W, see <sup>65</sup> Ga	-	3E+3	1E-6	4E-9	-	-
31	Gallium-67	D, see <sup>65</sup> Ga	7E+3	1E+4	6E-6	2E-8	1E-4	1E-3
		W, see <sup>65</sup> Ga	-	1E+4	4E-6	1E-8	-	-
31	Gallium-68 <sup>2</sup>	D, see <sup>65</sup> Ga	2E+4	4E+4	2E-5	6E-8	2E-4	2E-3
		W, see <sup>65</sup> Ga	-	5E+4	2E-5	7E-8	-	-
31	Gallium-70 <sup>2</sup>	D, see <sup>65</sup> Ga	5E+4	2E+5	7E-5	2E-7	-	-
			St wall					
			(7E+4)	-	-	-	1E-3	1E-2
		W, see <sup>65</sup> Ga	-	2E+5	8E-5	3E-7	-	-
31	Gallium-72	D, see <sup>65</sup> Ga	1E+3	4E+3	1E-6	5E-9	2E-5	2E-4
		W, see <sup>65</sup> Ga	-	3E+3	1E-6	4E-9	-	-
31	Gallium-73	D, see <sup>65</sup> Ga	5E+3	2E+4	6E-6	2E-8	7E-5	7E-4
		W, see <sup>65</sup> Ga	-	2E+4	6E-6	2E-8	-	-
32	Germanium-66	D, all compounds except those given for W	2E+4	3E+4	1E-5	4E-8	3E-4	3E-3
		W, oxides, sulfides, and halides	-	2E+4	8E-6	3E-8	-	-
32	Germanium-67 <sup>2</sup>	D, see <sup>66</sup> Ge	3E+4	9E+4	4E-5	1E-7	-	-
			St wall					
			(4E+4)	-	-	-	6E-4	6E-3
		W, see <sup>66</sup> Ge	-	1E+5	4E-5	1E-7	-	-
32	Germanium-68	D, see <sup>66</sup> Ge	5E+3	4E+3	2E-6	5E-9	6E-5	6E-4
		W, see <sup>66</sup> Ge	-	1E+2	4E-8	1E-10	-	-
32	Germanium-69	D, see <sup>66</sup> Ge	1E+4	2E+4	6E-6	2E-8	2E-4	2E-3
		W, see <sup>66</sup> Ge	-	8E+3	3E-6	1E-8	-	-

Atomic Radio-nuclide No.	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
		Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	Monthly Average Concentration (μCi/ml)
		Oral Ingestion	INHALATION		Air (μCi/ml)	Water (μCi/ml)	
			ALI (μCi)	ALI (μCi)			
32 Germanium-71	D, see <sup>66</sup> Ge	5E+5	4E+5	2E-4	6E-7	7E-3	7E-2
	W, see <sup>66</sup> Ge	-	4E+4	2E-5	6E-8	-	-
32 Germanium-75 <sup>2</sup>	D, see <sup>66</sup> Ge	4E+4	8E+4	3E-5	1E-7	-	-
	St wall	(7E+4)	-	-	-	9E-4	9E-3
32 Germanium-77	W, see <sup>66</sup> Ge	-	8E+4	4E-5	1E-7	-	-
	D, see <sup>66</sup> Ge	9E+3	1E+4	4E-6	1E-8	1E-4	1E-3
32 Germanium-78 <sup>2</sup>	W, see <sup>66</sup> Ge	-	6E+3	2E-6	8E-9	-	-
	D, see <sup>66</sup> Ge	2E+4	2E+4	9E-6	3E-8	-	-
33 Arsenic-69 <sup>2</sup>	St wall	(2E+4)	-	-	-	3E-4	3E-3
	W, see <sup>66</sup> Ge	-	2E+4	9E-6	3E-8	-	-
33 Arsenic-70 <sup>2</sup>	W, all compounds	3E+4	1E+5	5E-5	2E-7	-	-
	St wall	(4E+4)	-	-	-	6E-4	6E-3
33 Arsenic-70 <sup>2</sup>	W, all compounds	1E+4	5E+4	2E-5	7E-8	2E-4	2E-3
33 Arsenic-71	W, all compounds	4E+3	5E+3	2E-6	6E-9	5E-5	5E-4
33 Arsenic-72	W, all compounds	9E+2	1E+3	6E-7	2E-9	1E-5	1E-4
33 Arsenic-73	W, all compounds	8E+3	2E+3	7E-7	2E-9	1E-4	1E-3
33 Arsenic-74	W, all compounds	1E+3	8E+2	3E-7	1E-9	2E-5	2E-4
33 Arsenic-76	W, all compounds	1E+3	1E+3	6E-7	2E-9	1E-5	1E-4
33 Arsenic-77	W, all compounds	4E+3	5E+3	2E-6	7E-9	-	-
	LLI wall	(5E+3)	-	-	-	6E-5	6E-4
33 Arsenic-78 <sup>2</sup>	W, all compounds	8E+3	2E+4	9E-6	3E-8	1E-4	1E-3
34 Selenium-70 <sup>2</sup>	D, all compounds except those given for W	2E+4	4E+4	2E-5	5E-8	1E-4	1E-3
	W, oxides, hydroxides, carbides, and elemental Se	1E+4	4E+4	2E-5	6E-8	-	-
34 Selenium-73m <sup>2</sup>	D, see <sup>70</sup> Se	6E+4	2E+5	6E-5	2E-7	4E-4	4E-3
	W, see <sup>70</sup> Se	3E+4	1E+5	6E-5	2E-7	-	-
34 Selenium-73	D, see <sup>70</sup> Se	3E+3	1E+4	5E-6	2E-8	4E-5	4E-4
	W, see <sup>70</sup> Se	-	2E+4	7E-6	2E-8	-	-
34 Selenium-75	D, see <sup>70</sup> Se	5E+2	7E+2	3E-7	1E-9	7E-6	7E-5
	W, see <sup>70</sup> Se	-	6E+2	3E-7	8E-10	-	-
34 Selenium-79	D, see <sup>70</sup> Se	6E+2	8E+2	3E-7	1E-9	8E-6	8E-5
	W, see <sup>70</sup> Se	-	6E+2	2E-7	8E-10	-	-
34 Selenium-81m <sup>2</sup>	D, see <sup>70</sup> Se	4E+4	7E+4	3E-5	9E-8	3E-4	3E-3
	W, see <sup>70</sup> Se	2E+4	7E+4	3E-5	1E-7	-	-

Atomic Radio-nuclide No.	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers	
		Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	Monthly Average Concentration (μCi/ml)	
		Oral Ingestion ALI (μCi)	INHALATION ALI (μCi)      DAC (μCi/ml)		Air (μCi/ml)	Water (μCi/ml)		
34	Selenium-81 <sup>2</sup>	D, see <sup>70</sup> Se	6E+4	2E+5	9E-5	3E-7	-	-
		St wall	(8E+4)	-	-	-	1E-3	1E-2
		W, see <sup>70</sup> Se	-	2E+5	1E-4	3E-7	-	-
34	Selenium-83 <sup>2</sup>	D, see <sup>70</sup> Se	4E+4	1E+5	5E-5	2E-7	4E-4	4E-3
		W, see <sup>70</sup> Se	3E+4	1E+5	5E-5	2E-7	-	-
35	Bromine-74m <sup>2</sup>	D, bromides of H, Li, Na, K, Rb, Cs, and Fr	1E+4	4E+4	2E-5	5E-8	-	-
		St wall	(2E+4)	-	-	-	3E-4	3E-3
		W, bromides of lanthanides, Be, Mg, Ca, Sr, Ba, Ra, Al, Ga, In, Tl, Ge, Sn, Pb, As, Sb, Bi, Fe, Ru, Os, Co, Rh, Ir, Ni, Pd, Pt, Cu, Ag, Au, Zn, Cd, Hg, Sc, Y, Ti, Zr, Hf, V, Nb, Ta, Mn, Tc, and Re	-	4E+4	2E-5	6E-8	-	-
35	Bromine-74 <sup>2</sup>	D, see <sup>74m</sup> Br	2E+4	7E+4	3E-5	1E-7	-	-
		St wall	(4E+4)	-	-	-	5E-4	5E-3
		W, see <sup>74m</sup> Br	-	8E+4	4E-5	1E-7	-	-
35	Bromine-75 <sup>2</sup>	D, see <sup>74m</sup> Br	3E+4	5E+4	2E-5	7E-8	-	-
		St wall	(4E+4)	-	-	-	5E-4	5E-3
		W, see <sup>74m</sup> Br	-	5E+4	2E-5	7E-8	-	-
35	Bromine-76	D, see <sup>74m</sup> Br	4E+3	5E+3	2E-6	7E-9	5E-5	5E-4
		W, see <sup>74m</sup> Br	-	4E+3	2E-6	6E-9	-	-
35	Bromine-77	D, see <sup>74m</sup> Br	2E+4	2E+4	1E-5	3E-8	2E-4	2E-3
		W, see <sup>74m</sup> Br	-	2E+4	8E-6	3E-8	-	-
35	Bromine-80m	D, see <sup>74m</sup> Br	2E+4	2E+4	7E-6	2E-8	3E-4	3E-3
		W, see <sup>74m</sup> Br	-	1E+4	6E-6	2E-8	-	-
35	Bromine-80 <sup>2</sup>	D, see <sup>74m</sup> Br	5E+4	2E+5	8E-5	3E-7	-	-
		St wall	(9E+4)	-	-	-	1E-3	1E-2
		W, see <sup>74m</sup> Br	-	2E+5	9E-5	3E-7	-	-
35	Bromine-82	D, see <sup>74m</sup> Br	3E+3	4E+3	2E-6	6E-9	4E-5	4E-4
		W, see <sup>74m</sup> Br	-	4E+3	2E-6	5E-9	-	-
35	Bromine-83	D, see <sup>74m</sup> Br	5E+4	6E+4	3E-5	9E-8	-	-
		St wall	(7E+4)	-	-	-	9E-4	9E-3
		W, see <sup>74m</sup> Br	-	6E+4	3E-5	9E-8	-	-

Atomic Radio-nuclide No.	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers	
		Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	Monthly Average Concentration (μCi/ml)	
		Oral Ingestion ALI (μCi)	INHALATION		Air (μCi/ml)	Water (μCi/ml)		
			ALI (μCi)	DAC (μCi/ml)				
35	Bromine-84 <sup>2</sup>	D, see <sup>74m</sup> Br	2E+4	6E+4	2E-5	8E-8	-	-
			St wall					
			(3E+4)	-	-	-	4E-4	4E-3
		W, see <sup>74m</sup> Br	-	6E+4	3E-5	9E-8	-	-
36	Krypton-74 <sup>2</sup>	Submersion <sup>1</sup>	-	-	3E-6	1E-8	-	-
36	Krypton-76	Submersion <sup>1</sup>	-	-	9E-6	4E-8	-	-
36	Krypton-77 <sup>2</sup>	Submersion <sup>1</sup>	-	-	4E-6	2E-8	-	-
36	Krypton-79	Submersion <sup>1</sup>	-	-	2E-5	7E-8	-	-
36	Krypton-81	Submersion <sup>1</sup>	-	-	7E-4	3E-6	-	-
36	Krypton-83m <sup>2</sup>	Submersion <sup>1</sup>	-	-	1E-2	5E-5	-	-
36	Krypton-85m	Submersion <sup>1</sup>	-	-	2E-5	1E-7	-	-
36	Krypton-85	Submersion <sup>1</sup>	-	-	1E-4	7E-7	-	-
36	Krypton-87 <sup>2</sup>	Submersion <sup>1</sup>	-	-	5E-6	2E-8	-	-
36	Krypton-88	Submersion <sup>1</sup>	-	-	2E-6	9E-9	-	-
37	Rubidium-79 <sup>2</sup>	D, all compounds	4E+4	1E+5	5E-5	2E-7	-	-
			St wall					
			(6E+4)	-	-	-	8E-4	8E-3
37	Rubidium-81m <sup>2</sup>	D, all compounds	2E+5	3E+5	1E-4	5E-7	-	-
			St wall					
			(3E+5)	-	-	-	4E-3	4E-2
37	Rubidium-81	D, all compounds	4E+4	5E+4	2E-5	7E-8	5E-4	5E-3
37	Rubidium-82m	D, all compounds	1E+4	2E+4	7E-6	2E-8	2E-4	2E-3
37	Rubidium-83	D, all compounds	6E+2	1E+3	4E-7	1E-9	9E-6	9E-5
37	Rubidium-84	D, all compounds	5E+2	8E+2	3E-7	1E-9	7E-6	7E-5
37	Rubidium-86	D, all compounds	5E+2	8E+2	3E-7	1E-9	7E-6	7E-5
37	Rubidium-87	D, all compounds	1E+3	2E+3	6E-7	2E-9	1E-5	1E-4
37	Rubidium-88 <sup>2</sup>	D, all compounds	2E+4	6E+4	3E-5	9E-8	-	-
			St wall					
			(3E+4)	-	-	-	4E-4	4E-3
37	Rubidium-89 <sup>2</sup>	D, all compounds	4E+4	1E+5	6E-5	2E-7	-	-
			St wall					
			(6E+4)	-	-	-	9E-4	9E-3
38	Strontium-80 <sup>2</sup>	D, all soluble compounds except SrTiO	4E+3	1E+4	5E-6	2E-8	6E-5	6E-4
		Y, all insoluble compounds and SrTiO	-	1E+4	5E-6	2E-8	-	-
38	Strontium-81 <sup>2</sup>	D, see <sup>80</sup> Sr	3E+4	8E+4	3E-5	1E-7	3E-4	3E-3
		Y, see <sup>80</sup> Sr	2E+4	8E+4	3E-5	1E-7	-	-
38	Strontium-82	D, see <sup>80</sup> Sr	3E+2	4E+2	2E-7	6E-10	-	-
			LLI wall					
			(2E+2)	-	-	-	3E-6	3E-5
		Y, see <sup>80</sup> Sr	2E+2	9E+1	4E-8	1E-10	-	-



Atomic Radio-nuclide No.	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers	
		Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	Monthly Average Concentration (μCi/ml)	
		Oral Ingestion ALI (μCi)	INHALATION ALI (μCi)      DAC (μCi/ml)		Air (μCi/ml)	Water (μCi/ml)		
38	Strontium-83	D, see <sup>80</sup> Sr	3E+3	7E+3	3E-6	1E-8	3E-5	3E-4
		Y, see <sup>80</sup> Sr	2E+3	4E+3	1E-6	5E-9	-	-
38	Strontium-85m <sup>2</sup>	D, see <sup>80</sup> Sr	2E+5	6E+5	3E-4	9E-7	3E-3	3E-2
		Y, see <sup>80</sup> Sr	-	8E+5	4E-4	1E-6	-	-
38	Strontium-85	D, see <sup>80</sup> Sr	3E+3	3E+3	1E-6	4E-9	4E-5	4E-4
		Y, see <sup>80</sup> Sr	-	2E+3	6E-7	2E-9	-	-
38	Strontium-87m	D, see <sup>80</sup> Sr	5E+4	1E+5	5E-5	2E-7	6E-4	6E-3
		Y, see <sup>80</sup> Sr	4E+4	2E+5	6E-5	2E-7	-	-
38	Strontium-89	D, see <sup>80</sup> Sr	6E+2	8E+2	4E-7	1E-9	-	-
		LLI wall	(6E+2)	-	-	-	8E-6	8E-5
		Y, see <sup>80</sup> Sr	5E+2	1E+2	6E-8	2E-10	-	-
38	Strontium-90	D, see <sup>80</sup> Sr	3E+1	2E+1	8E-9	-	-	-
		Bone surf	(4E+1)	(2E+1)	-	3E-11	5E-7	5E-6
		Y, see <sup>80</sup> Sr	-	4E+0	2E-9	6E-12	-	-
38	Strontium-91	D, see <sup>80</sup> Sr	2E+3	6E+3	2E-6	8E-9	2E-5	2E-4
		Y, see <sup>80</sup> Sr	-	4E+3	1E-6	5E-9	-	-
38	Strontium-92	D, see <sup>80</sup> Sr	3E+3	9E+3	4E-6	1E-8	4E-5	4E-4
		Y, see <sup>80</sup> Sr	-	7E+3	3E-6	9E-9	-	-
39	Yttrium-86m <sup>2</sup>	W, all compounds except those given for Y	2E+4	6E+4	2E-5	8E-8	3E-4	3E-3
		Y, oxides and hydroxides	-	5E+4	2E-5	8E-8	-	-
39	Yttrium-86	W, see <sup>86m</sup> Y	1E+3	3E+3	1E-6	5E-9	2E-5	2E-4
		Y, see <sup>86m</sup> Y	-	3E+3	1E-6	5E-9	-	-
39	Yttrium-87	W, see <sup>86m</sup> Y	2E+3	3E+3	1E-6	5E-9	3E-5	3E-4
		Y, see <sup>86m</sup> Y	-	3E+3	1E-6	5E-9	-	-
39	Yttrium-88	W, see <sup>86m</sup> Y	1E+3	3E+2	1E-7	3E-10	1E-5	1E-4
		Y, see <sup>86m</sup> Y	-	2E+2	1E-7	3E-10	-	-
39	Yttrium-90m	W, see <sup>86m</sup> Y	8E+3	1E+4	5E-6	2E-8	1E-4	1E-3
		Y, see <sup>86m</sup> Y	-	1E+4	5E-6	2E-8	-	-
39	Yttrium-90	W, see <sup>86m</sup> Y	4E+2	7E+2	3E-7	9E-10	-	-
		LLI wall	(5E+2)	-	-	-	7E-6	7E-5
		Y, see <sup>86m</sup> Y	-	6E+2	3E-7	9E-10	-	-
39	Yttrium-91m <sup>2</sup>	W, see <sup>86m</sup> Y	1E+5	2E+5	1E-4	3E-7	2E-3	2E-2
		Y, see <sup>86m</sup> Y	-	2E+5	7E-5	2E-7	-	-
39	Yttrium-91	W, see <sup>86m</sup> Y	5E+2	2E+2	7E-8	2E-10	-	-
		LLI wall	(6E+2)	-	-	-	8E-6	8E-5
		Y, see <sup>86m</sup> Y	-	1E+2	5E-8	2E-10	-	-

Atomic Radio-nuclide No.	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
		Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	Monthly Average Concentration (μCi/ml)
		Oral Ingestion	INHALATION		Air (μCi/ml)	Water (μCi/ml)	
			ALI (μCi)	ALI (μCi)			
39 Yttrium-92	W, see <sup>86m</sup> Y	3E+3	9E+3	4E-6	1E-8	4E-5	4E-4
	Y, see <sup>86m</sup> Y	-	8E+3	3E-6	1E-8	-	-
39 Yttrium-93	W, see <sup>86m</sup> Y	1E+3	3E+3	1E-6	4E-9	2E-5	2E-4
	Y, see <sup>86m</sup> Y	-	2E+3	1E-6	3E-9	-	-
39 Yttrium-94 <sup>2</sup>	W, see <sup>86m</sup> Y	2E+4 St wall	8E+4	3E-5	1E-7	-	-
		(3E+4)	-	-	-	4E-4	4E-3
39 Yttrium-95 <sup>2</sup>	Y, see <sup>86m</sup> Y	-	8E+4	3E-5	1E-7	-	-
	W, see <sup>86m</sup> Y	4E+4 St wall	2E+5	6E-5	2E-7	-	-
		(5E+4)	-	-	-	7E-4	7E-3
40 Zirconium-86	Y, see <sup>86m</sup> Y	-	1E+5	6E-5	2E-7	-	-
	D, all compounds except those given for W and Y	1E+3	4E+3	2E-6	6E-9	2E-5	2E-4
	W, oxides, hydroxides, halides, and nitrates	-	3E+3	1E-6	4E-9	-	-
	Y, carbide	-	2E+3	1E-6	3E-9	-	-
40 Zirconium-88	D, see <sup>86</sup> Zr	4E+3	2E+2	9E-8	3E-10	5E-5	5E-4
	W, see <sup>86</sup> Zr	-	5E+2	2E-7	7E-10	-	-
	Y, see <sup>86</sup> Zr	-	3E+2	1E-7	4E-10	-	-
40 Zirconium-89	D, see <sup>86</sup> Zr	2E+3	4E+3	1E-6	5E-9	2E-5	2E-4
	W, see <sup>86</sup> Zr	-	2E+3	1E-6	3E-9	-	-
	Y, see <sup>86</sup> Zr	-	2E+3	1E-6	3E-9	-	-
40 Zirconium-93	D, see <sup>86</sup> Zr	1E+3 Bone surf	6E+0 Bone surf	3E-9	-	-	-
		(3E+3)	(2E+1)	-	2E-11	4E-5	4E-4
	W, see <sup>86</sup> Zr	-	2E+1 Bone surf	1E-8	-	-	-
		-	(6E+1)	-	9E-11	-	-
	Y, see <sup>86</sup> Zr	-	6E+1 Bone surf	2E-8	-	-	-
		-	(7E+1)	-	9E-11	-	-
40 Zirconium-95	D, see <sup>86</sup> Zr	1E+3	1E+2 Bone surf	5E-8	-	2E-5	2E-4
		-	(3E+2)	-	4E-10	-	-
	W, see <sup>86</sup> Zr	-	4E+2	2E-7	5E-10	-	-
	Y, see <sup>86</sup> Zr	-	3E+2	1E-7	4E-10	-	-
40 Zirconium-97	D, see <sup>86</sup> Zr	6E+2	2E+3	8E-7	3E-9	9E-6	9E-5
	W, see <sup>86</sup> Zr	-	1E+3	6E-7	2E-9	-	-
	Y, see <sup>86</sup> Zr	-	1E+3	5E-7	2E-9	-	-

Atomic Radio-nuclide No.	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
		Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	Monthly Average Concentration (μCi/ml)
		Oral Ingestion	INHALATION		Air (μCi/ml)	Water (μCi/ml)	
			ALI (μCi)	ALI (μCi)			
41 Niobium-88 <sup>2</sup>	W, all compounds except those given for Y	5E+4	2E+5	9E-5	3E-7	-	-
		St wall (7E+4)	-	-	-	1E-3	1E-2
	Y, oxides and hydroxides	-	2E+5	9E-5	3E-7	-	-
41 Niobium-89 <sup>2</sup> (66 min)	W, see <sup>88</sup> Nb	1E+4	4E+4	2E-5	6E-8	1E-4	1E-3
	Y, see <sup>88</sup> Nb	-	4E+4	2E-5	5E-8	-	-
41 Niobium-89 (122 min)	W, see <sup>88</sup> Nb	5E+3	2E+4	8E-6	3E-8	7E-5	7E-4
	Y, see <sup>88</sup> Nb	-	2E+4	6E-6	2E-8	-	-
41 Niobium-90	W, see <sup>88</sup> Nb	1E+3	3E+3	1E-6	4E-9	1E-5	1E-4
	Y, see <sup>88</sup> Nb	-	2E+3	1E-6	3E-9	-	-
41 Niobium-93m	W, see <sup>88</sup> Nb	9E+3	2E+3	8E-7	3E-9	-	-
		LLI wall (1E+4)	-	-	-	2E-4	2E-3
	Y, see <sup>88</sup> Nb	-	2E+2	7E-8	2E-10	-	-
41 Niobium-94	W, see <sup>88</sup> Nb	9E+2	2E+2	8E-8	3E-10	1E-5	1E-4
	Y, see <sup>88</sup> Nb	-	2E+1	6E-9	2E-11	-	-
41 Niobium-95m	W, see <sup>88</sup> Nb	2E+3	3E+3	1E-6	4E-9	-	-
		LLI wall (2E+3)	-	-	-	3E-5	3E-4
	Y, see <sup>88</sup> Nb	-	2E+3	9E-7	3E-9	-	-
41 Niobium-95	W, see <sup>88</sup> Nb	2E+3	1E+3	5E-7	2E-9	3E-5	3E-4
	Y, see <sup>88</sup> Nb	-	1E+3	5E-7	2E-9	-	-
41 Niobium-96	W, see <sup>88</sup> Nb	1E+3	3E+3	1E-6	4E-9	2E-5	2E-4
	Y, see <sup>88</sup> Nb	-	2E+3	1E-6	3E-9	-	-
41 Niobium-97 <sup>2</sup>	W, see <sup>88</sup> Nb	2E+4	8E+4	3E-5	1E-7	3E-4	3E-3
	Y, see <sup>88</sup> Nb	-	7E+4	3E-5	1E-7	-	-
41 Niobium-98 <sup>2</sup>	W, see <sup>88</sup> Nb	1E+4	5E+4	2E-5	8E-8	2E-4	2E-3
	Y, see <sup>88</sup> Nb	-	5E+4	2E-5	7E-8	-	-
42 Molybdenum-90	D, all compounds except those given for Y	4E+3	7E+3	3E-6	1E-8	3E-5	3E-4
	Y, oxides, hydroxides, and MoS	2E+3	5E+3	2E-6	6E-9	-	-
42 Molybdenum-93m	D, see <sup>90</sup> Mo	9E+3	2E+4	7E-6	2E-8	6E-5	6E-4
	Y, see <sup>90</sup> Mo	4E+3	1E+4	6E-6	2E-8	-	-
42 Molybdenum-93	D, see <sup>90</sup> Mo	4E+3	5E+3	2E-6	8E-9	5E-5	5E-4
	Y, see <sup>90</sup> Mo	2E+4	2E+2	8E-8	2E-10	-	-
42 Molybdenum-99	D, see <sup>90</sup> Mo	2E+3	3E+3	1E-6	4E-9	-	-
		LLI wall (1E+3)	-	-	-	2E-5	2E-4
	Y, see <sup>90</sup> Mo	1E+3	1E+3	6E-7	2E-9	-	-

Atomic Radio-nuclide No.	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
		Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	Monthly Average Concentration ( $\mu\text{Ci/ml}$ )
		Oral Ingestion ALI ( $\mu\text{Ci}$ )	INHALATION		Air ( $\mu\text{Ci/ml}$ )	Water ( $\mu\text{Ci/ml}$ )	
			ALI ( $\mu\text{Ci}$ )	DAC ( $\mu\text{Ci/ml}$ )			
42 Molybdenum-101 <sup>2</sup>	D, see <sup>90</sup> Mo	4E+4 St wall	1E+5	6E-5	2E-7	-	-
		(5E+4)	-	-	-	7E-4	7E-3
	Y, see <sup>90</sup> Mo	-	1E+5	6E-5	2E-7	-	-
43 Technetium-93m <sup>2</sup>	D, all compounds except those given for W  W, oxides, hydroxides, halides, and nitrates	7E+4	2E+5	6E-5	2E-7	1E-3	1E-2
		-	3E+5	1E-4	4E-7	-	-
43 Technetium-93	D, see <sup>93m</sup> Tc	3E+4	7E+4	3E-5	1E-7	4E-4	4E-3
	W, see <sup>93m</sup> Tc	-	1E+5	4E-5	1E-7	-	-
43 Technetium-94m <sup>2</sup>	D, see <sup>93m</sup> Tc	2E+4	4E+4	2E-5	6E-8	3E-4	3E-3
	W, see <sup>93m</sup> Tc	-	6E+4	2E-5	8E-8	-	-
43 Technetium-94	D, see <sup>93m</sup> Tc	9E+3	2E+4	8E-6	3E-8	1E-4	1E-3
	W, see <sup>93m</sup> Tc	-	2E+4	1E-5	3E-8	-	-
43 Technetium-95m	D, see <sup>93m</sup> Tc	4E+3	5E+3	2E-6	8E-9	5E-5	5E-4
	W, see <sup>93m</sup> Tc	-	2E+3	8E-7	3E-9	-	-
43 Technetium-95	D, see <sup>93m</sup> Tc	1E+4	2E+4	9E-6	3E-8	1E-4	1E-3
	W, see <sup>93m</sup> Tc	-	2E+4	8E-6	3E-8	-	-
43 Technetium-96m <sup>2</sup>	D, see <sup>93m</sup> Tc	2E+5	3E+5	1E-4	4E-7	2E-3	2E-2
	W, see <sup>93m</sup> Tc	-	2E+5	1E-4	3E-7	-	-
43 Technetium-96	D, see <sup>93m</sup> Tc	2E+3	3E+3	1E-6	5E-9	3E-5	3E-4
	W, see <sup>93m</sup> Tc	-	2E+3	9E-7	3E-9	-	-
43 Technetium-97m	D, see <sup>93m</sup> Tc	5E+3 St wall	7E+3	3E-6	-	6E-5	6E-4
		(7E+3)	-	1E-8	-	-	-
	W, see <sup>93m</sup> Tc	-	1E+3	5E-7	2E-9	-	-
43 Technetium-97	D, see <sup>93m</sup> Tc	4E+4	5E+4	2E-5	7E-8	5E-4	5E-3
	W, see <sup>93m</sup> Tc	-	6E+3	2E-6	8E-9	-	-
43 Technetium-98	D, see <sup>93m</sup> Tc	1E+3	2E+3	7E-7	2E-9	1E-5	1E-4
	W, see <sup>93m</sup> Tc	-	3E+2	1E-7	4E-10	-	-
43 Technetium-99m	D, see <sup>93m</sup> Tc	8E+4	2E+5	6E-5	2E-7	1E-3	1E-2
	W, see <sup>93m</sup> Tc	-	2E+5	1E-4	3E-7	-	-
43 Technetium-99	D, see <sup>93m</sup> Tc	4E+3 St wall	5E+3	2E-6	-	6E-5	6E-4
		(6E+3)	-	8E-9	-	-	-
	W, see <sup>93m</sup> Tc	-	7E+2	3E-7	9E-10	-	-
43 Technetium-101 <sup>2</sup>	D, see <sup>93m</sup> Tc	9E+4 St wall	3E+5	1E-4	5E-7	-	-
		(1E+5)	-	-	-	2E-3	2E-2
	W, see <sup>93m</sup> Tc	-	4E+5	2E-4	5E-7	-	-

Atomic Radio-nuclide No.	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers	
		Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	Monthly Average Concentration (μCi/ml)	
		Oral Ingestion	INHALATION		Air (μCi/ml)	Water (μCi/ml)		
			ALI (μCi)	ALI (μCi)				DAC (μCi/ml)
43	Technetium-104 <sup>2</sup>	D, see <sup>93m</sup> Tc	2E+4	7E+4	3E-5	1E-7	-	-
			St wall (3E+4)	-	-	-	4E-4	4E-3
44	Ruthenium-94 <sup>2</sup>	W, see <sup>93m</sup> Tc	-	9E+4	4E-5	1E-7	-	-
		D, all compounds except those given for W and Y	2E+4	4E+4	2E-5	6E-8	2E-4	2E-3
		W, halides	-	6E+4	3E-5	9E-8	-	-
44	Ruthenium-97	Y, oxides and hydroxides	-	6E+4	2E-5	8E-8	-	-
		D, see <sup>94</sup> Ru	8E+3	2E+4	8E-6	3E-8	1E-4	1E-3
		W, see <sup>94</sup> Ru	-	1E+4	5E-6	2E-8	-	-
44	Ruthenium-103	Y, see <sup>94</sup> Ru	-	1E+4	5E-6	2E-8	-	-
		D, see <sup>94</sup> Ru	2E+3	2E+3	7E-7	2E-9	3E-5	3E-4
		W, see <sup>94</sup> Ru	-	1E+3	4E-7	1E-9	-	-
44	Ruthenium-105	Y, see <sup>94</sup> Ru	-	6E+2	3E-7	9E-10	-	-
		D, see <sup>94</sup> Ru	5E+3	1E+4	6E-6	2E-8	7E-5	7E-4
		W, see <sup>94</sup> Ru	-	1E+4	6E-6	2E-8	-	-
44	Ruthenium-106	Y, see <sup>94</sup> Ru	-	1E+4	5E-6	2E-8	-	-
		D, see <sup>94</sup> Ru	2E+2	9E+1	4E-8	1E-10	-	-
		LLI wall (2E+2)	-	-	-	-	3E-6	3E-5
45	Rhodium-99m	W, see <sup>94</sup> Ru	-	5E+1	2E-8	8E-11	-	-
		Y, see <sup>94</sup> Ru	-	1E+1	5E-9	2E-11	-	-
		D, all compounds except those given for W and Y	2E+4	6E+4	2E-5	8E-8	2E-4	2E-3
45	Rhodium-99	W, halides	-	8E+4	3E-5	1E-7	-	-
		Y, oxides and hydroxides	-	7E+4	3E-5	9E-8	-	-
		D, see <sup>99m</sup> Rh	2E+3	3E+3	1E-6	4E-9	3E-5	3E-4
45	Rhodium-100	W, see <sup>99m</sup> Rh	-	2E+3	9E-7	3E-9	-	-
		Y, see <sup>99m</sup> Rh	-	2E+3	8E-7	3E-9	-	-
		D, see <sup>99m</sup> Rh	2E+3	5E+3	2E-6	7E-9	2E-5	2E-4
45	Rhodium-101m	W, see <sup>99m</sup> Rh	-	4E+3	2E-6	6E-9	-	-
		Y, see <sup>99m</sup> Rh	-	4E+3	2E-6	5E-9	-	-
		D, see <sup>99m</sup> Rh	6E+3	1E+4	5E-6	2E-8	8E-5	8E-4
45	Rhodium-101	W, see <sup>99m</sup> Rh	-	8E+3	4E-6	1E-8	-	-
		Y, see <sup>99m</sup> Rh	-	8E+3	3E-6	1E-8	-	-
		D, see <sup>99m</sup> Rh	2E+3	5E+2	2E-7	7E-10	3E-5	3E-4
45	Rhodium-101	W, see <sup>99m</sup> Rh	-	8E+2	3E-7	1E-9	-	-
		Y, see <sup>99m</sup> Rh	-	2E+2	6E-8	2E-10	-	-

Atomic Radio-nuclide No.	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers	
		Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	Monthly Average Concentration (μCi/ml)	
		Oral Ingestion	INHALATION		Air (μCi/ml)	Water (μCi/ml)		
			ALI (μCi)	ALI (μCi)				DAC (μCi/ml)
45 Rhodium-102m	D, see <sup>99m</sup> Rh	1E+3	5E+2	2E-7	7E-10	-	-	
		LLI wall						
		(1E+3)	-	-	-	2E-5	2E-4	
45 Rhodium-102	W, see <sup>99m</sup> Rh	-	4E+2	2E-7	5E-10	-	-	
	Y, see <sup>99m</sup> Rh	-	1E+2	5E-8	2E-10	-	-	
	D, see <sup>99m</sup> Rh	6E+2	9E+1	4E-8	1E-10	8E-6	8E-5	
45 Rhodium-103m <sup>2</sup>	W, see <sup>99m</sup> Rh	-	2E+2	7E-8	2E-10	-	-	
	Y, see <sup>99m</sup> Rh	-	6E+1	2E-8	8E-11	-	-	
	D, see <sup>99m</sup> Rh	4E+5	1E+6	5E-4	2E-6	6E-3	6E-2	
45 Rhodium-105	W, see <sup>99m</sup> Rh	-	1E+6	5E-4	2E-6	-	-	
	Y, see <sup>99m</sup> Rh	-	1E+6	5E-4	2E-6	-	-	
	D, see <sup>99m</sup> Rh	4E+3	1E+4	5E-6	2E-8	-	-	
45 Rhodium-106m	D, see <sup>99m</sup> Rh	LLI wall						
		(4E+3)	-	-	-	5E-5	5E-4	
		W, see <sup>99m</sup> Rh	-	6E+3	3E-6	9E-9	-	-
45 Rhodium-107 <sup>2</sup>	Y, see <sup>99m</sup> Rh	-	6E+3	2E-6	8E-9	-	-	
	D, see <sup>99m</sup> Rh	8E+3	3E+4	1E-5	4E-8	1E-4	1E-3	
	W, see <sup>99m</sup> Rh	-	4E+4	2E-5	5E-8	-	-	
46 Palladium-100	Y, see <sup>99m</sup> Rh	-	4E+4	1E-5	5E-8	-	-	
	D, see <sup>99m</sup> Rh	7E+4	2E+5	1E-4	3E-7	-	-	
	St wall							
46 Palladium-101	D, all compounds except those given for W and Y	(9E+4)	-	-	-	1E-3	1E-2	
		W, see <sup>99m</sup> Rh	-	3E+5	1E-4	4E-7	-	-
		Y, see <sup>99m</sup> Rh	-	3E+5	1E-4	3E-7	-	-
46 Palladium-103	W, nitrates	-	1E+3	5E-7	2E-9	-	-	
	Y, oxides and hydroxides	-	1E+3	6E-7	2E-9	-	-	
	D, see <sup>100</sup> Pd	1E+4	3E+4	1E-5	5E-8	2E-4	2E-3	
46 Palladium-107	W, see <sup>100</sup> Pd	-	3E+4	1E-5	5E-8	-	-	
	Y, see <sup>100</sup> Pd	-	3E+4	1E-5	4E-8	-	-	
	D, see <sup>100</sup> Pd	6E+3	6E+3	3E-6	9E-9	-	-	
46 Palladium-107 <sup>2</sup>	D, see <sup>100</sup> Pd	LLI wall						
		(7E+3)	-	-	-	1E-4	1E-3	
		W, see <sup>100</sup> Pd	-	4E+3	2E-6	6E-9	-	-
46 Palladium-107 <sup>2</sup>	Y, see <sup>100</sup> Pd	-	4E+3	1E-6	5E-9	-	-	
	D, see <sup>100</sup> Pd	3E+4	2E+4	9E-6	-	-	-	
	LLI wall Kidneys							
46 Palladium-107 <sup>2</sup>	D, see <sup>100</sup> Pd	(4E+4)	(2E+4)	-	3E-8	5E-4	5E-3	
		W, see <sup>100</sup> Pd	-	7E+3	3E-6	1E-8	-	-
		Y, see <sup>100</sup> Pd	-	4E+2	2E-7	6E-10	-	-

Atomic Radio-nuclide No.	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
		Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	Monthly Average Concentration ( $\mu\text{Ci/ml}$ )
		Oral Ingestion	INHALATION		Air ( $\mu\text{Ci/ml}$ )	Water ( $\mu\text{Ci/ml}$ )	
		ALI ( $\mu\text{Ci}$ )	ALI ( $\mu\text{Ci}$ )	DAC ( $\mu\text{Ci/ml}$ )			
46 Palladium-109	D, see $^{100}\text{Pd}$	2E+3	6E+3	3E-6	9E-9	3E-5	3E-4
	W, see $^{100}\text{Pd}$	-	5E+3	2E-6	8E-9	-	-
	Y, see $^{100}\text{Pd}$	-	5E+3	2E-6	6E-9	-	-
47 Silver-102 <sup>2</sup>	D, all compounds except those given for W and Y	5E+4 St wall	2E+5	8E-5	2E-7	-	-
		(6E+4)	-	-	-	9E-4	9E-3
	W, nitrates and sulfides	-	2E+5	9E-5	3E-7	-	-
47 Silver-103 <sup>2</sup>	Y, oxides and hydroxides	-	2E+5	8E-5	3E-7	-	-
		4E+4	1E+5	4E-5	1E-7	5E-4	5E-3
		-	1E+5	5E-5	2E-7	-	-
47 Silver-104m <sup>2</sup>	D, see $^{102}\text{Ag}$	-	1E+5	5E-5	2E-7	-	-
		3E+4	9E+4	4E-5	1E-7	4E-4	4E-3
		-	1E+5	5E-5	2E-7	-	-
47 Silver-104 <sup>2</sup>	Y, see $^{102}\text{Ag}$	-	1E+5	5E-5	2E-7	-	-
		2E+4	7E+4	3E-5	1E-7	3E-4	3E-3
		-	1E+5	6E-5	2E-7	-	-
47 Silver-105	D, see $^{102}\text{Ag}$	-	1E+5	6E-5	2E-7	-	-
		3E+3	1E+3	4E-7	1E-9	4E-5	4E-4
		-	2E+3	7E-7	2E-9	-	-
47 Silver-106m	Y, see $^{102}\text{Ag}$	-	2E+3	7E-7	2E-9	-	-
		8E+2	7E+2	3E-7	1E-9	1E-5	1E-4
		-	9E+2	4E-7	1E-9	-	-
47 Silver-106 <sup>2</sup>	D, see $^{102}\text{Ag}$	-	9E+2	4E-7	1E-9	-	-
		6E+4 St wall	2E+5	8E-5	3E-7	-	-
		(6E+4)	-	-	-	9E-4	9E-3
47 Silver-108m	W, see $^{102}\text{Ag}$	-	2E+5	9E-5	3E-7	-	-
		-	2E+5	8E-5	3E-7	-	-
		6E+2	2E+2	8E-8	3E-10	9E-6	9E-5
47 Silver-110m	D, see $^{102}\text{Ag}$	-	3E+2	1E-7	4E-10	-	-
		-	2E+1	1E-8	3E-11	-	-
		5E+2	1E+2	5E-8	2E-10	6E-6	6E-5
47 Silver-111	Y, see $^{102}\text{Ag}$	-	2E+2	8E-8	3E-10	-	-
		-	9E+1	4E-8	1E-10	-	-
		9E+2 LLI wall	2E+3 Liver	6E-7	-	-	-
47 Silver-111	D, see $^{102}\text{Ag}$	(1E+3)	(2E+3)	-	2E-9	2E-5	2E-4
		-	9E+2	4E-7	1E-9	-	-
		-	9E+2	4E-7	1E-9	-	-

Atomic Radio-nuclide No.	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
		Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	Monthly Average Concentration (µCi/ml)
		Oral Ingestion	INHALATION		Air (µCi/ml)	Water (µCi/ml)	
			ALI (µCi)	ALI (µCi)			
47 Silver-112	D, see <sup>102</sup> Ag	3E+3	8E+3	3E-6	1E-8	4E-5	4E-4
	W, see <sup>102</sup> Ag	-	1E+4	4E-6	1E-8	-	-
	Y, see <sup>102</sup> Ag	-	9E+3	4E-6	1E-8	-	-
47 Silver-115 <sup>2</sup>	D, see <sup>102</sup> Ag	3E+4 St wall	9E+4	4E-5	1E-7	-	-
		(3E+4)	-	-	-	4E-4	4E-3
	W, see <sup>102</sup> Ag	-	9E+4	4E-5	1E-7	-	-
48 Cadmium-104 <sup>2</sup>	Y, see <sup>102</sup> Ag	-	8E+4	3E-5	1E-7	-	-
	D, all compounds except those given for W and Y	2E+4	7E+4	3E-5	9E-8	3E-4	3E-3
	W, sulfides, halides, and nitrates	-	1E+5	5E-5	2E-7	-	-
48 Cadmium-107	Y, oxides and hydroxides	-	1E+5	5E-5	2E-7	-	-
	D, see <sup>104</sup> Cd	2E+4	5E+4	2E-5	8E-8	3E-4	3E-3
	W, see <sup>104</sup> Cd	-	6E+4	2E-5	8E-8	-	-
48 Cadmium-109	Y, see <sup>104</sup> Cd	-	5E+4	2E-5	7E-8	-	-
	D, see <sup>104</sup> Cd	3E+2	4E+1	1E-8	-	-	-
		Kidneys	Kidneys				
48 Cadmium-113m		(4E+2)	(5E+1)	-	7E-11	6E-6	6E-5
	W, see <sup>104</sup> Cd	-	1E+2	5E-8	-	-	-
		-	(1E+2)	-	2E-10	-	-
48 Cadmium-113	Y, see <sup>104</sup> Cd	-	1E+2	5E-8	2E-10	-	-
	D, see <sup>104</sup> Cd	2E+1	2E+0	1E-9	-	-	-
		Kidneys	Kidneys				
48 Cadmium-115m		(4E+1)	(4E+0)	-	5E-12	5E-7	5E-6
	W, see <sup>104</sup> Cd	-	8E+0	4E-9	-	-	-
		-	(1E+1)	-	2E-11	-	-
48 Cadmium-115	Y, see <sup>104</sup> Cd	-	1E+1	5E-9	2E-11	-	-
	D, see <sup>104</sup> Cd	2E+1	2E+0	9E-10	-	-	-
		Kidneys	Kidneys				
48 Cadmium-115m		(3E+1)	(3E+0)	-	5E-12	4E-7	4E-6
	W, see <sup>104</sup> Cd	-	8E+0	3E-9	-	-	-
		-	(1E+1)	-	2E-11	-	-
48 Cadmium-115m	Y, see <sup>104</sup> Cd	-	1E+1	6E-9	2E-11	-	-
	D, see <sup>104</sup> Cd	3E+2	5E+1	2E-8	-	4E-6	4E-5
		-	(8E+1)	-	1E-10	-	-
48 Cadmium-115m	W, see <sup>104</sup> Cd	-	1E+2	5E-8	2E-10	-	-
	Y, see <sup>104</sup> Cd	-	1E+2	6E-8	2E-10	-	-



Atomic Radio-nuclide No.	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers	
		Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	Monthly Average Concentration (μCi/ml)	
		Oral Ingestion	INHALATION		Air (μCi/ml)	Water (μCi/ml)		
			ALI (μCi)	ALI (μCi)				DAC (μCi/ml)
48 Cadmium-115	D, see <sup>104</sup> Cd	9E+2	1E+3	6E-7	2E-9	-	-	
		LLI wall						
		(1E+3)	-	-	-	1E-5	1E-4	
48 Cadmium-117m	D, see <sup>104</sup> Cd	5E+3	1E+4	5E-6	2E-8	6E-5	6E-4	
		W, see <sup>104</sup> Cd	-	2E+4	7E-6	2E-8	-	-
		Y, see <sup>104</sup> Cd	-	1E+4	6E-6	2E-8	-	-
48 Cadmium-117	D, see <sup>104</sup> Cd	5E+3	1E+4	5E-6	2E-8	6E-5	6E-4	
		W, see <sup>104</sup> Cd	-	2E+4	7E-6	2E-8	-	-
		Y, see <sup>104</sup> Cd	-	1E+4	6E-6	2E-8	-	-
49 Indium-109	D, all compounds except those given for W	2E+4	4E+4	2E-5	6E-8	3E-4	3E-3	
		W, oxides, hydroxides, halides, and nitrates	-	6E+4	3E-5	9E-8	-	-
49 Indium-110 <sup>2</sup> (69.1 min)	D, see <sup>109</sup> In	2E+4	4E+4	2E-5	6E-8	2E-4	2E-3	
		W, see <sup>109</sup> In	-	6E+4	2E-5	8E-8	-	-
49 Indium-110 (4.9 h)	D, see <sup>109</sup> In	5E+3	2E+4	7E-6	2E-8	7E-5	7E-4	
		W, see <sup>109</sup> In	-	2E+4	8E-6	3E-8	-	-
49 Indium-111	D, see <sup>109</sup> In	4E+3	6E+3	3E-6	9E-9	6E-5	6E-4	
		W, see <sup>109</sup> In	-	6E+3	3E-6	9E-9	-	-
49 Indium-112 <sup>2</sup>	D, see <sup>109</sup> In	2E+5	6E+5	3E-4	9E-7	2E-3	2E-2	
		W, see <sup>109</sup> In	-	7E+5	3E-4	1E-6	-	-
49 Indium-113m <sup>2</sup>	D, see <sup>109</sup> In	5E+4	1E+5	6E-5	2E-7	7E-4	7E-3	
		W, see <sup>109</sup> In	-	2E+5	8E-5	3E-7	-	-
49 Indium-114m	D, see <sup>109</sup> In	3E+2	6E+1	3E-8	9E-11	-	-	
		LLI wall						
		(4E+2)	-	-	-	5E-6	5E-5	
49 Indium-115m	D, see <sup>109</sup> In	1E+4	4E+4	2E-5	6E-8	2E-4	2E-3	
		W, see <sup>109</sup> In	-	5E+4	2E-5	7E-8	-	-
49 Indium-115	D, see <sup>109</sup> In	4E+1	1E+0	6E-10	2E-12	5E-7	5E-6	
		W, see <sup>109</sup> In	-	5E+0	2E-9	8E-12	-	-
49 Indium-116m <sup>2</sup>	D, see <sup>109</sup> In	2E+4	8E+4	3E-5	1E-7	3E-4	3E-3	
		W, see <sup>109</sup> In	-	1E+5	5E-5	2E-7	-	-
49 Indium-117m <sup>2</sup>	D, see <sup>109</sup> In	1E+4	3E+4	1E-5	5E-8	2E-4	2E-3	
		W, see <sup>109</sup> In	-	4E+4	2E-5	6E-8	-	-
49 Indium-117 <sup>2</sup>	D, see <sup>109</sup> In	6E+4	2E+5	7E-5	2E-7	8E-4	8E-3	
		W, see <sup>109</sup> In	-	2E+5	9E-5	3E-7	-	-
49 Indium-119m <sup>2</sup>	D, see <sup>109</sup> In	4E+4	1E+5	5E-5	2E-7	-	-	
		St wall						
		(5E+4)	-	-	-	7E-4	7E-3	
	W, see <sup>109</sup> In	-	1E+5	6E-5	2E-7	-	-	

Atomic Radio-nuclide No.	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
		Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	Monthly Average Concentration (μCi/ml)
		Oral Ingestion	INHALATION		Air (μCi/ml)	Water (μCi/ml)	
			ALI (μCi)	ALI (μCi)			
50 Tin-110	D, all compounds except those given for W	4E+3	1E+4	5E-6	2E-8	5E-5	5E-4
	W, sulfides, oxides, hydroxides, halides, nitrates, and stannic phosphate	-	1E+4	5E-6	2E-8	-	-
50 Tin-111 <sup>2</sup>	D, see <sup>110</sup> Sn	7E+4	2E+5	9E-5	3E-7	1E-3	1E-2
	W, see <sup>110</sup> Sn	-	3E+5	1E-4	4E-7	-	-
50 Tin-113	D, see <sup>110</sup> Sn	2E+3	1E+3	5E-7	2E-9	-	-
	LLI wall	(2E+3)	-	-	-	3E-5	3E-4
	W, see <sup>110</sup> Sn	-	5E+2	2E-7	8E-10	-	-
50 Tin-117m	D, see <sup>110</sup> Sn	2E+3	1E+3	5E-7	-	-	-
	LLI wall	(2E+3)	(2E+3)	-	3E-9	3E-5	3E-4
	Bone surf	-	-	-	-	-	-
	W, see <sup>110</sup> Sn	-	1E+3	6E-7	2E-9	-	-
50 Tin-119m	D, see <sup>110</sup> Sn	3E+3	2E+3	1E-6	3E-9	-	-
	LLI wall	(4E+3)	-	-	-	6E-5	6E-4
	W, see <sup>110</sup> Sn	-	1E+3	4E-7	1E-9	-	-
50 Tin-121m	D, see <sup>110</sup> Sn	3E+3	9E+2	4E-7	1E-9	-	-
	LLI wall	(4E+3)	-	-	-	5E-5	5E-4
	W, see <sup>110</sup> Sn	-	5E+2	2E-7	8E-10	-	-
50 Tin-121	D, see <sup>110</sup> Sn	6E+3	2E+4	6E-6	2E-8	-	-
	LLI wall	(6E+3)	-	-	-	8E-5	8E-4
	W, see <sup>110</sup> Sn	-	1E+4	5E-6	2E-8	-	-
50 Tin-123m <sup>2</sup>	D, see <sup>110</sup> Sn	5E+4	1E+5	5E-5	2E-7	7E-4	7E-3
	W, see <sup>110</sup> Sn	-	1E+5	6E-5	2E-7	-	-
50 Tin-123	D, see <sup>110</sup> Sn	5E+2	6E+2	3E-7	9E-10	-	-
	LLI wall	(6E+2)	-	-	-	9E-6	9E-5
	W, see <sup>110</sup> Sn	-	2E+2	7E-8	2E-10	-	-
50 Tin-125	D, see <sup>110</sup> Sn	4E+2	9E+2	4E-7	1E-9	-	-
	LLI wall	(5E+2)	-	-	-	6E-6	6E-5
	W, see <sup>110</sup> Sn	-	4E+2	1E-7	5E-10	-	-
50 Tin-126	D, see <sup>110</sup> Sn	3E+2	6E+1	2E-8	8E-11	4E-6	4E-5
	W, see <sup>110</sup> Sn	-	7E+1	3E-8	9E-11	-	-
50 Tin-127	D, see <sup>110</sup> Sn	7E+3	2E+4	8E-6	3E-8	9E-5	9E-4
	W, see <sup>110</sup> Sn	-	2E+4	8E-6	3E-8	-	-
50 Tin-128 <sup>2</sup>	D, see <sup>110</sup> Sn	9E+3	3E+4	1E-5	4E-8	1E-4	1E-3
	W, see <sup>110</sup> Sn	-	4E+4	1E-5	5E-8	-	-

Atomic Radio-nuclide No.	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers	
		Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	Monthly Average Concentration (μCi/ml)	
		Oral Ingestion ALI (μCi)	INHALATION ALI (μCi)      DAC (μCi/ml)		Air (μCi/ml)	Water (μCi/ml)		
51	Antimony-115 <sup>2</sup>	D, all compounds except those given for W	8E+4	2E+5	1E-4	3E-7	1E-3	1E-2
		W, oxides, hydroxides, halides, sulfides, sulfates, and nitrates	-	3E+5	1E-4	4E-7	-	-
51	Antimony-116m <sup>2</sup>	D, see <sup>115</sup> Sb	2E+4	7E+4	3E-5	1E-7	3E-4	3E-3
		W, see <sup>115</sup> Sb	-	1E+5	6E-5	2E-7	-	-
51	Antimony-116 <sup>2</sup>	D, see <sup>115</sup> Sb	7E+4	3E+5	1E-4	4E-7	-	-
		St wall	(9E+4)	-	-	-	1E-3	1E-2
		W, see <sup>115</sup> Sb	-	3E+5	1E-4	5E-7	-	-
51	Antimony-117	D, see <sup>115</sup> Sb	7E+4	2E+5	9E-5	3E-7	9E-4	9E-3
		W, see <sup>115</sup> Sb	-	3E+5	1E-4	4E-7	-	-
51	Antimony-118m	D, see <sup>115</sup> Sb	6E+3	2E+4	8E-6	3E-8	7E-5	7E-4
		W, see <sup>115</sup> Sb	5E+3	2E+4	9E-6	3E-8	-	-
51	Antimony-119	D, see <sup>115</sup> Sb	2E+4	5E+4	2E-5	6E-8	2E-4	2E-3
		W, see <sup>115</sup> Sb	2E+4	3E+4	1E-5	4E-8	-	-
51	Antimony-120 <sup>2</sup> (16 min)	D, see <sup>115</sup> Sb	1E+5	4E+5	2E-4	6E-7	-	-
		St wall	(2E+5)	-	-	-	2E-3	2E-2
		W, see <sup>115</sup> Sb	-	5E+5	2E-4	7E-7	-	-
51	Antimony-120 (5.76 d)	D, see <sup>115</sup> Sb	1E+3	2E+3	9E-7	3E-9	1E-5	1E-4
		W, see <sup>115</sup> Sb	9E+2	1E+3	5E-7	2E-9	-	-
51	Antimony-122	D, see <sup>115</sup> Sb	8E+2	2E+3	1E-6	3E-9	-	-
		LLI wall	(8E+2)	-	-	-	1E-5	1E-4
		W, see <sup>115</sup> Sb	7E+2	1E+3	4E-7	2E-9	-	-
51	Antimony-124m <sup>2</sup>	D, see <sup>115</sup> Sb	3E+5	8E+5	4E-4	1E-6	3E-3	3E-2
		W, see <sup>115</sup> Sb	2E+5	6E+5	2E-4	8E-7	-	-
51	Antimony-124	D, see <sup>115</sup> Sb	6E+2	9E+2	4E-7	1E-9	7E-6	7E-5
		W, see <sup>115</sup> Sb	5E+2	2E+2	1E-7	3E-10	-	-
51	Antimony-125	D, see <sup>115</sup> Sb	2E+3	2E+3	1E-6	3E-9	3E-5	3E-4
		W, see <sup>115</sup> Sb	-	5E+2	2E-7	7E-10	-	-
51	Antimony-126m <sup>2</sup>	D, see <sup>115</sup> Sb	5E+4	2E+5	8E-5	3E-7	-	-
		St wall	(7E+4)	-	-	-	9E-4	9E-3
		W, see <sup>115</sup> Sb	-	2E+5	8E-5	3E-7	-	-
51	Antimony-126	D, see <sup>115</sup> Sb	6E+2	1E+3	5E-7	2E-9	7E-6	7E-5
		W, see <sup>115</sup> Sb	5E+2	5E+2	2E-7	7E-10	-	-
51	Antimony-127	D, see <sup>115</sup> Sb	8E+2	2E+3	9E-7	3E-9	-	-
		LLI wall	(8E+2)	-	-	-	1E-5	1E-4
		W, see <sup>115</sup> Sb	7E+2	9E+2	4E-7	1E-9	-	-



Atomic Radio-nuclide No.	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers	
		Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	Monthly Average Concentration ( $\mu\text{Ci/ml}$ )	
		Oral Ingestion ALI ( $\mu\text{Ci}$ )	INHALATION ALI ( $\mu\text{Ci}$ )      DAC ( $\mu\text{Ci/ml}$ )		Air ( $\mu\text{Ci/ml}$ )	Water ( $\mu\text{Ci/ml}$ )		
52	Tellurium-127m	D, see $^{116}\text{Te}$	6E+2	3E+2	1E-7	-	9E-6	9E-5
				Bone surf				
			-	(4E+2)	-	6E-10	-	-
		W, see $^{116}\text{Te}$	-	3E+2	1E-7	4E-10	-	-
52	Tellurium-127	D, see $^{116}\text{Te}$	7E+3	2E+4	9E-6	3E-8	1E-4	1E-3
		W, see $^{116}\text{Te}$	-	2E+4	7E-6	2E-8	-	-
52	Tellurium-129m	D, see $^{116}\text{Te}$	5E+2	6E+2	3E-7	9E-10	7E-6	7E-5
		W, see $^{116}\text{Te}$	-	2E+2	1E-7	3E-10	-	-
52	Tellurium-129 <sup>2</sup>	D, see $^{116}\text{Te}$	3E+4	6E+4	3E-5	9E-8	4E-4	4E-3
		W, see $^{116}\text{Te}$	-	7E+4	3E-5	1E-7	-	-
52	Tellurium-131m	D, see $^{116}\text{Te}$	3E+2	4E+2	2E-7	-	-	-
			Thyroid	Thyroid				
			(6E+2)	(1E+3)	-	2E-9	8E-6	8E-5
		W, see $^{116}\text{Te}$	-	4E+2	2E-7	-	-	-
			Thyroid	Thyroid				
			-	(9E+2)	-	1E-9	-	-
52	Tellurium-131 <sup>2</sup>	D, see $^{116}\text{Te}$	3E+3	5E+3	2E-6	-	-	-
			Thyroid	Thyroid				
			(6E+3)	(1E+4)	-	2E-8	8E-5	8E-4
		W, see $^{116}\text{Te}$	-	5E+3	2E-6	-	-	-
			Thyroid	Thyroid				
			-	(1E+4)	-	2E-8	-	-
52	Tellurium-132	D, see $^{116}\text{Te}$	2E+2	2E+2	9E-8	-	-	-
			Thyroid	Thyroid				
			(7E+2)	(8E+2)	-	1E-9	9E-6	9E-5
		W, see $^{116}\text{Te}$	-	2E+2	9E-8	-	-	-
			Thyroid	Thyroid				
			-	(6E+2)	-	9E-10	-	-
52	Tellurium-133m <sup>2</sup>	D, see $^{116}\text{Te}$	3E+3	5E+3	2E-6	-	-	-
			Thyroid	Thyroid				
			(6E+3)	(1E+4)	-	2E-8	9E-5	9E-4
		W, see $^{116}\text{Te}$	-	5E+3	2E-6	-	-	-
			Thyroid	Thyroid				
			-	(1E+4)	-	2E-8	-	-
52	Tellurium-133 <sup>2</sup>	D, see $^{116}\text{Te}$	1E+4	2E+4	9E-6	-	-	-
			Thyroid	Thyroid				
			(3E+4)	(6E+4)	-	8E-8	4E-4	4E-3
		W, see $^{116}\text{Te}$	-	2E+4	9E-6	-	-	-
			Thyroid	Thyroid				
			-	(6E+4)	-	8E-8	-	-

Atomic Radio-nuclide No.	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
		Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	Monthly Average Concentration (μCi/ml)
		Oral Ingestion	INHALATION		Air (μCi/ml)	Water (μCi/ml)	
		ALI (μCi)	ALI (μCi)	DAC (μCi/ml)			
52 Tellurium-134 <sup>2</sup>	D, see <sup>116</sup> Te	2E+4	2E+4	1E-5	-	-	-
		Thyroid (2E+4)	Thyroid (5E+4)	-	7E-8	3E-4	3E-3
	W, see <sup>116</sup> Te	-	2E+4	1E-5	-	-	-
		-	Thyroid (5E+4)	-	7E-8	-	-
53 Iodine-120m <sup>2</sup>	D, all compounds	1E+4	2E+4	9E-6	3E-8	-	-
		Thyroid (1E+4)	-	-	-	2E-4	2E-3
53 Iodine-120 <sup>2</sup>	D, all compounds	4E+3	9E+3	4E-6	-	-	-
		Thyroid (8E+3)	Thyroid (1E+4)	-	2E-8	1E-4	1E-3
53 Iodine-121	D, all compounds	1E+4	2E+4	8E-6	-	-	-
		Thyroid (3E+4)	Thyroid (5E+4)	-	7E-8	4E-4	4E-3
53 Iodine-123	D, all compounds	3E+3	6E+3	3E-6	-	-	-
		Thyroid (1E+4)	Thyroid (2E+4)	-	2E-8	1E-4	1E-3
53 Iodine-124	D, all compounds	5E+1	8E+1	3E-8	-	-	-
		Thyroid (2E+2)	Thyroid (3E+2)	-	4E-10	2E-6	2E-5
53 Iodine-125	D, all compounds	4E+1	6E+1	3E-8	-	-	-
		Thyroid (1E+2)	Thyroid (2E+2)	-	3E-10	2E-6	2E-5
53 Iodine-126	D, all compounds	2E+1	4E+1	1E-8	-	-	-
		Thyroid (7E+1)	Thyroid (1E+2)	-	2E-10	1E-6	1E-5
53 Iodine-128 <sup>2</sup>	D, all compounds	4E+4	1E+5	5E-5	2E-7	-	-
		St wall (6E+4)	-	-	-	8E-4	8E-3
53 Iodine-129	D, all compounds	5E+0	9E+0	4E-9	-	-	-
		Thyroid (2E+1)	Thyroid (3E+1)	-	4E-11	2E-7	2E-6
53 Iodine-130	D, all compounds	4E+2	7E+2	3E-7	-	-	-
		Thyroid (1E+3)	Thyroid (2E+3)	-	3E-9	2E-5	2E-4
53 Iodine-131	D, all compounds	3E+1	5E+1	2E-8	-	-	-
		Thyroid (9E+1)	Thyroid (2E+2)	-	2E-10	1E-6	1E-5
53 Iodine-132m <sup>2</sup>	D, all compounds	4E+3	8E+3	4E-6	-	-	-
		Thyroid (1E+4)	Thyroid (2E+4)	-	3E-8	1E-4	1E-3

Atomic Radio-nuclide No.	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
		Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	Monthly Average Concentration ( $\mu\text{Ci/ml}$ )
		Oral Ingestion	INHALATION		Air ( $\mu\text{Ci/ml}$ )	Water ( $\mu\text{Ci/ml}$ )	
		ALI ( $\mu\text{Ci}$ )	ALI ( $\mu\text{Ci}$ )	DAC ( $\mu\text{Ci/ml}$ )			
53 Iodine-132	D, all compounds	4E+3	8E+3	3E-6	-	-	-
		Thyroid (9E+3)	Thyroid (1E+4)	-	2E-8	1E-4	1E-3
53 Iodine-133	D, all compounds	1E+2	3E+2	1E-7	-	-	-
		Thyroid (5E+2)	Thyroid (9E+2)	-	1E-9	7E-6	7E-5
53 Iodine-134 <sup>2</sup>	D, all compounds	2E+4	5E+4	2E-5	6E-8	-	-
		Thyroid (3E+4)	-	-	-	4E-4	4E-3
53 Iodine-135	D, all compounds	8E+2	2E+3	7E-7	-	-	-
		Thyroid (3E+3)	Thyroid (4E+3)	-	6E-9	3E-5	3E-4
54 Xenon-120 <sup>2</sup>	Submersion <sup>1</sup>	-	-	1E-5	4E-8	-	-
54 Xenon-121 <sup>2</sup>	Submersion <sup>1</sup>	-	-	2E-6	1E-8	-	-
54 Xenon-122	Submersion <sup>1</sup>	-	-	7E-5	3E-7	-	-
54 Xenon-123	Submersion <sup>1</sup>	-	-	6E-6	3E-8	-	-
54 Xenon-125	Submersion <sup>1</sup>	-	-	2E-5	7E-8	-	-
54 Xenon-127	Submersion <sup>1</sup>	-	-	1E-5	6E-8	-	-
54 Xenon-129m	Submersion <sup>1</sup>	-	-	2E-4	9E-7	-	-
54 Xenon-131m	Submersion <sup>1</sup>	-	-	4E-4	2E-6	-	-
54 Xenon-133m	Submersion <sup>1</sup>	-	-	1E-4	6E-7	-	-
54 Xenon-133	Submersion <sup>1</sup>	-	-	1E-4	5E-7	-	-
54 Xenon-135m <sup>2</sup>	Submersion <sup>1</sup>	-	-	9E-6	4E-8	-	-
54 Xenon-135	Submersion <sup>1</sup>	-	-	1E-5	7E-8	-	-
54 Xenon-138 <sup>2</sup>	Submersion <sup>1</sup>	-	-	4E-6	2E-8	-	-
55 Cesium-125 <sup>2</sup>	D, all compounds	5E+4	1E+5	6E-5	2E-7	-	-
		St wall (9E+4)	-	-	-	1E-3	1E-2
55 Cesium-127	D, all compounds	6E+4	9E+4	4E-5	1E-7	9E-4	9E-3
55 Cesium-129	D, all compounds	2E+4	3E+4	1E-5	5E-8	3E-4	3E-3
55 Cesium-130 <sup>2</sup>	D, all compounds	6E+4	2E+5	8E-5	3E-7	-	-
		St wall (1E+5)	-	-	-	1E-3	1E-2
55 Cesium-131	D, all compounds	2E+4	3E+4	1E-5	4E-8	3E-4	3E-3
55 Cesium-132	D, all compounds	3E+3	4E+3	2E-6	6E-9	4E-5	4E-4
55 Cesium-134m	D, all compounds	1E+5	1E+5	6E-5	2E-7	-	-
		St wall (1E+5)	-	-	-	2E-3	2E-2
55 Cesium-134	D, all compounds	7E+1	1E+2	4E-8	2E-10	9E-7	9E-6
55 Cesium-135m <sup>2</sup>	D, all compounds	1E+5	2E+5	8E-5	3E-7	1E-3	1E-2
55 Cesium-135	D, all compounds	7E+2	1E+3	5E-7	2E-9	1E-5	1E-4
55 Cesium-136	D, all compounds	4E+2	7E+2	3E-7	9E-10	6E-6	6E-5

Atomic Radio-nuclide No.	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers	
		Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	Monthly Average Concentration ( $\mu$ Ci/ml)	
		Oral Ingestion	INHALATION		Air ( $\mu$ Ci/ml)	Water ( $\mu$ Ci/ml)		
			ALI ( $\mu$ Ci)	ALI ( $\mu$ Ci)				DAC ( $\mu$ Ci/ml)
55	Cesium-137	D, all compounds	1E+2	2E+2	6E-8	2E-10	1E-6	1E-5
55	Cesium-138 <sup>2</sup>	D, all compounds	2E+4	6E+4	2E-5	8E-8	-	-
			St wall (3E+4)	-	-	-	4E-4	4E-3
56	Barium-126 <sup>2</sup>	D, all compounds	6E+3	2E+4	6E-6	2E-8	8E-5	8E-4
56	Barium-128	D, all compounds	5E+2	2E+3	7E-7	2E-9	7E-6	7E-5
56	Barium-131m <sup>2</sup>	D, all compounds	4E+5	1E+6	6E-4	2E-6	-	-
			St wall (5E+5)	-	-	-	7E-3	7E-2
56	Barium-131	D, all compounds	3E+3	8E+3	3E-6	1E-8	4E-5	4E-4
56	Barium-133m	D, all compounds	2E+3	9E+3	4E-6	1E-8	-	-
			LLI wall (3E+3)	-	-	-	4E-5	4E-4
56	Barium-133	D, all compounds	2E+3	7E+2	3E-7	9E-10	2E-5	2E-4
56	Barium-135m	D, all compounds	3E+3	1E+4	5E-6	2E-8	4E-5	4E-4
56	Barium-139 <sup>2</sup>	D, all compounds	1E+4	3E+4	1E-5	4E-8	2E-4	2E-3
56	Barium-140	D, all compounds	5E+2	1E+3	6E-7	2E-9	-	-
			LLI wall (6E+2)	-	-	-	8E-6	8E-5
56	Barium-141 <sup>2</sup>	D, all compounds	2E+4	7E+4	3E-5	1E-7	3E-4	3E-3
56	Barium-142 <sup>2</sup>	D, all compounds	5E+4	1E+5	6E-5	2E-7	7E-4	7E-3
57	Lanthanum-131 <sup>2</sup>	D, all compounds except those given for W	5E+4	1E+5	5E-5	2E-7	6E-4	6E-3
		W, oxides and hydroxides	-	2E+5	7E-5	2E-7	-	-
57	Lanthanum-132	D, see <sup>131</sup> La	3E+3	1E+4	4E-6	1E-8	4E-5	4E-4
		W, see <sup>131</sup> La	-	1E+4	5E-6	2E-8	-	-
57	Lanthanum-135	D, see <sup>131</sup> La	4E+4	1E+5	4E-5	1E-7	5E-4	5E-3
		W, see <sup>131</sup> La	-	9E+4	4E-5	1E-7	-	-
57	Lanthanum-137	D, see <sup>131</sup> La	1E+4	6E+1	3E-8	-	2E-4	2E-3
			Liver	(7E+1)	-	1E-10	-	-
		W, see <sup>131</sup> La	-	3E+2	1E-7	-	-	-
			Liver	(3E+2)	-	4E-10	-	-
57	Lanthanum-138	D, see <sup>131</sup> La	9E+2	4E+0	1E-9	5E-12	1E-5	1E-4
		W, see <sup>131</sup> La	-	1E+1	6E-9	2E-11	-	-
57	Lanthanum-140	D, see <sup>131</sup> La	6E+2	1E+3	6E-7	2E-9	9E-6	9E-5
		W, see <sup>131</sup> La	-	1E+3	5E-7	2E-9	-	-
57	Lanthanum-141	D, see <sup>131</sup> La	4E+3	9E+3	4E-6	1E-8	5E-5	5E-4
		W, see <sup>131</sup> La	-	1E+4	5E-6	2E-8	-	-
57	Lanthanum-142 <sup>2</sup>	D, see <sup>131</sup> La	8E+3	2E+4	9E-6	3E-8	1E-4	1E-3
		W, see <sup>131</sup> La	-	3E+4	1E-5	5E-8	-	-



Atomic Radio-nuclide No.	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers	
		Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	Monthly Average Concentration (μCi/ml)	
		Oral Ingestion	INHALATION		Air (μCi/ml)	Water (μCi/ml)		
			ALI (μCi)	ALI (μCi)				DAC (μCi/ml)
57	Lanthanum-143 <sup>2</sup>	D, see <sup>131</sup> La	4E+4	1E+5	4E-5	1E-7	-	-
			St wall (4E+4)	-	-	-	5E-4	5E-3
		W, see <sup>131</sup> La	-	9E+4	4E-5	1E-7	-	-
58	Cerium-134	W, all compounds except those given for Y	5E+2	7E+2	3E-7	1E-9	-	-
			LLI wall (6E+2)	-	-	-	8E-6	8E-5
		Y, oxides, hydroxides, and fluorides	-	7E+2	3E-7	9E-10	-	-
58	Cerium-135	W, see <sup>134</sup> Ce	2E+3	4E+3	2E-6	5E-9	2E-5	2E-4
		Y, see <sup>134</sup> Ce	-	4E+3	1E-6	5E-9	-	-
58	Cerium-137m	W, see <sup>134</sup> Ce	2E+3	4E+3	2E-6	6E-9	-	-
			LLI wall (2E+3)	-	-	-	3E-5	3E-4
		Y, see <sup>134</sup> Ce	-	4E+3	2E-6	5E-9	-	-
58	Cerium-137	W, see <sup>134</sup> Ce	5E+4	1E+5	6E-5	2E-7	7E-4	7E-3
		Y, see <sup>134</sup> Ce	-	1E+5	5E-5	2E-7	-	-
58	Cerium-139	W, see <sup>134</sup> Ce	5E+3	8E+2	3E-7	1E-9	7E-5	7E-4
		Y, see <sup>134</sup> Ce	-	7E+2	3E-7	9E-10	-	-
58	Cerium-141	W, see <sup>134</sup> Ce	2E+3	7E+2	3E-7	1E-9	-	-
			LLI wall (2E+3)	-	-	-	3E-5	3E-4
		Y, see <sup>134</sup> Ce	-	6E+2	2E-7	8E-10	-	-
58	Cerium-143	W, see <sup>134</sup> Ce	1E+3	2E+3	8E-7	3E-9	-	-
			LLI wall (1E+3)	-	-	-	2E-5	2E-4
		Y, see <sup>134</sup> Ce	-	2E+3	7E-7	2E-9	-	-
58	Cerium-144	W, see <sup>134</sup> Ce	2E+2	3E+1	1E-8	4E-11	-	-
			LLI wall (3E+2)	-	-	-	3E-6	3E-5
		Y, see <sup>134</sup> Ce	-	1E+1	6E-9	2E-11	-	-
59	Praseodymium-136 <sup>2</sup>	W, all compounds except those given for Y	5E+4	2E+5	1E-4	3E-7	-	-
			St wall (7E+4)	-	-	-	1E-3	1E-2
		Y, oxides, hydroxides, carbides, and fluorides	-	2E+5	9E-5	3E-7	-	-
59	Praseodymium-137 <sup>2</sup>	W, see <sup>136</sup> Pr	4E+4	2E+5	6E-5	2E-7	5E-4	5E-3
		Y, see <sup>136</sup> Pr	-	1E+5	6E-5	2E-7	-	-
59	Praseodymium-138m	W, see <sup>136</sup> Pr	1E+4	5E+4	2E-5	8E-8	1E-4	1E-3
		Y, see <sup>136</sup> Pr	-	4E+4	2E-5	6E-8	-	-

Atomic Radio-nuclide No.	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
		Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	Monthly Average Concentration ( $\mu\text{Ci/ml}$ )
		Oral Ingestion ALI ( $\mu\text{Ci}$ )	INHALATION		Air ( $\mu\text{Ci/ml}$ )	Water ( $\mu\text{Ci/ml}$ )	
			ALI ( $\mu\text{Ci}$ )	DAC ( $\mu\text{Ci/ml}$ )			
59 Praseodymium-139	W, see <sup>136</sup> Pr	4E+4	1E+5	5E-5	2E-7	6E-4	6E-3
	Y, see <sup>136</sup> Pr	-	1E+5	5E-5	2E-7	-	-
59 Praseodymium-142m <sup>2</sup>	W, see <sup>136</sup> Pr	8E+4	2E+5	7E-5	2E-7	1E-3	1E-2
	Y, see <sup>136</sup> Pr	-	1E+5	6E-5	2E-7	-	-
59 Praseodymium-142	W, see <sup>136</sup> Pr	1E+3	2E+3	9E-7	3E-9	1E-5	1E-4
	Y, see <sup>136</sup> Pr	-	2E+3	8E-7	3E-9	-	-
59 Praseodymium-143	W, see <sup>136</sup> Pr	9E+2	8E+2	3E-7	1E-9	-	-
		LLI wall (1E+3)	-	-	-	2E-5	2E-4
	Y, see <sup>136</sup> Pr	-	7E+2	3E-7	9E-10	-	-
59 Praseodymium-144 <sup>2</sup>	W, see <sup>136</sup> Pr	3E+4	1E+5	5E-5	2E-7	-	-
		St wall (4E+4)	-	-	-	6E-4	6E-3
	Y, see <sup>136</sup> Pr	-	1E+5	5E-5	2E-7	-	-
59 Praseodymium-145	W, see <sup>136</sup> Pr	3E+3	9E+3	4E-6	1E-8	4E-5	4E-4
	Y, see <sup>136</sup> Pr	-	8E+3	3E-6	1E-8	-	-
59 Praseodymium-147 <sup>2</sup>	W, see <sup>136</sup> Pr	5E+4	2E+5	8E-5	3E-7	-	-
		St wall (8E+4)	-	-	-	1E-3	1E-2
	Y, see <sup>136</sup> Pr	-	2E+5	8E-5	3E-7	-	-
60 Neodymium-136 <sup>2</sup>	W, all compounds except those given for Y	1E+4	6E+4	2E-5	8E-8	2E-4	2E-3
	Y, oxides, hydroxides, carbides, and fluorides	-	5E+4	2E-5	8E-8	-	-
60 Neodymium-138	W, see <sup>136</sup> Nd	2E+3	6E+3	3E-6	9E-9	3E-5	3E-4
	Y, see <sup>136</sup> Nd	-	5E+3	2E-6	7E-9	-	-
60 Neodymium-139m	W, see <sup>136</sup> Nd	5E+3	2E+4	7E-6	2E-8	7E-5	7E-4
	Y, see <sup>136</sup> Nd	-	1E+4	6E-6	2E-8	-	-
60 Neodymium-139 <sup>2</sup>	W, see <sup>136</sup> Nd	9E+4	3E+5	1E-4	5E-7	1E-3	1E-2
	Y, see <sup>136</sup> Nd	-	3E+5	1E-4	4E-7	-	-
60 Neodymium-141	W, see <sup>136</sup> Nd	2E+5	7E+5	3E-4	1E-6	2E-3	2E-2
	Y, see <sup>136</sup> Nd	-	6E+5	3E-4	9E-7	-	-
60 Neodymium-147	W, see <sup>136</sup> Nd	1E+3	9E+2	4E-7	1E-9	-	-
		LLI wall (1E+3)	-	-	-	2E-5	2E-4
	Y, see <sup>136</sup> Nd	-	8E+2	4E-7	1E-9	-	-
60 Neodymium-149 <sup>2</sup>	W, see <sup>136</sup> Nd	1E+4	3E+4	1E-5	4E-8	1E-4	1E-3
	Y, see <sup>136</sup> Nd	-	2E+4	1E-5	3E-8	-	-
60 Neodymium-151 <sup>2</sup>	W, see <sup>136</sup> Nd	7E+4	2E+5	8E-5	3E-7	9E-4	9E-3
	Y, see <sup>136</sup> Nd	-	2E+5	8E-5	3E-7	-	-

Atomic Radio-nuclide No.	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers	
		Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	Monthly Average Concentration (μCi/ml)	
		Oral Ingestion	INHALATION		Air (μCi/ml)	Water (μCi/ml)		
		ALI (μCi)	ALI (μCi)	DAC (μCi/ml)				
61	Promethium-141 <sup>2</sup>	W, all compounds except those given for Y	5E+4	2E+5	8E-5	3E-7	-	-
		St wall	(6E+4)	-	-	-	8E-4	8E-3
		Y, oxides, hydroxides, carbides, and fluorides	-	2E+5	7E-5	2E-7	-	-
61	Promethium-143	W, see <sup>141</sup> Pm	5E+3	6E+2	2E-7	8E-10	7E-5	7E-4
		Y, see <sup>141</sup> Pm	-	7E+2	3E-7	1E-9	-	-
61	Promethium-144	W, see <sup>141</sup> Pm	1E+3	1E+2	5E-8	2E-10	2E-5	2E-4
		Y, see <sup>141</sup> Pm	-	1E+2	5E-8	2E-10	-	-
61	Promethium-145	W, see <sup>141</sup> Pm	1E+4	2E+2	7E-8	-	1E-4	1E-3
		Bone surf	-	(2E+2)	-	3E-10	-	-
		Y, see <sup>141</sup> Pm	-	2E+2	8E-8	3E-10	-	-
61	Promethium-146	W, see <sup>141</sup> Pm	2E+3	5E+1	2E-8	7E-11	2E-5	2E-4
		Y, see <sup>141</sup> Pm	-	4E+1	2E-8	6E-11	-	-
61	Promethium-147	W, see <sup>141</sup> Pm	4E+3	1E+2	5E-8	-	-	-
		Bone surf	(5E+3)	(2E+2)	-	3E-10	7E-5	7E-4
		Y, see <sup>141</sup> Pm	-	1E+2	6E-8	2E-10	-	-
61	Promethium-148m	W, see <sup>141</sup> Pm	7E+2	3E+2	1E-7	4E-10	1E-5	1E-4
		Y, see <sup>141</sup> Pm	-	3E+2	1E-7	5E-10	-	-
61	Promethium-148	W, see <sup>141</sup> Pm	4E+2	5E+2	2E-7	8E-10	-	-
		LLI wall	(5E+2)	-	-	-	7E-6	7E-5
		Y, see <sup>141</sup> Pm	-	5E+2	2E-7	7E-10	-	-
61	Promethium-149	W, see <sup>141</sup> Pm	1E+3	2E+3	8E-7	3E-9	-	-
		LLI wall	(1E+3)	-	-	-	2E-5	2E-4
		Y, see <sup>141</sup> Pm	-	2E+3	8E-7	2E-9	-	-
61	Promethium-150	W, see <sup>141</sup> Pm	5E+3	2E+4	8E-6	3E-8	7E-5	7E-4
		Y, see <sup>141</sup> Pm	-	2E+4	7E-6	2E-8	-	-
61	Promethium-151	W, see <sup>141</sup> Pm	2E+3	4E+3	1E-6	5E-9	2E-5	2E-4
		Y, see <sup>141</sup> Pm	-	3E+3	1E-6	4E-9	-	-
62	Samarium-141m <sup>2</sup>	W, all compounds	3E+4	1E+5	4E-5	1E-7	4E-4	4E-3
62	Samarium-141 <sup>2</sup>	W, all compounds	5E+4	2E+5	8E-5	2E-7	-	-
		St wall	(6E+4)	-	-	-	8E-4	8E-3
62	Samarium-142 <sup>2</sup>	W, all compounds	8E+3	3E+4	1E-5	4E-8	1E-4	1E-3
62	Samarium-145	W, all compounds	6E+3	5E+2	2E-7	7E-10	8E-5	8E-4
62	Samarium-146	W, all compounds	1E+1	4E-2	1E-11	-	-	-
		Bone surf		Bone surf				

Atomic Radio-nuclide No.	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers	
		Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	Monthly Average Concentration ( $\mu\text{Ci/ml}$ )	
		Oral Ingestion	INHALATION		Air ( $\mu\text{Ci/ml}$ )	Water ( $\mu\text{Ci/ml}$ )		
		ALI ( $\mu\text{Ci}$ )	ALI ( $\mu\text{Ci}$ )	DAC ( $\mu\text{Ci/ml}$ )				
		(3E+1)	(6E-2)	-	9E-14	3E-7	3E-6	
62	Samarium-147	W, all compounds	2E+1 Bone surf	4E-2 Bone surf	2E-11	-	-	-
		(3E+1)	(7E-2)	-	1E-13	4E-7	4E-6	
62	Samarium-151	W, all compounds	1E+4 LLI wall	1E+2 Bone surf	4E-8	-	-	-
		(1E+4)	(2E+2)	-	2E-10	2E-4	2E-3	
62	Samarium-153	W, all compounds	2E+3 LLI wall	3E+3	1E-6	4E-9	-	-
		(2E+3)	-	-	-	3E-5	3E-4	
62	Samarium-155 <sup>2</sup>	W, all compounds	6E+4 St wall	2E+5	9E-5	3E-7	-	-
		(8E+4)	-	-	-	1E-3	1E-2	
62	Samarium-156	W, all compounds	5E+3	9E+3	4E-6	1E-8	7E-5	7E-4
63	Europium-145	W, all compounds	2E+3	2E+3	8E-7	3E-9	2E-5	2E-4
63	Europium-146	W, all compounds	1E+3	1E+3	5E-7	2E-9	1E-5	1E-4
63	Europium-147	W, all compounds	3E+3	2E+3	7E-7	2E-9	4E-5	4E-4
63	Europium-148	W, all compounds	1E+3	4E+2	1E-7	5E-10	1E-5	1E-4
63	Europium-149	W, all compounds	1E+4	3E+3	1E-6	4E-9	2E-4	2E-3
63	Europium-150 (12.62 h)	W, all compounds	3E+3	8E+3	4E-6	1E-8	4E-5	4E-4
63	Europium-150 (34.2 y)	W, all compounds	8E+2	2E+1	8E-9	3E-11	1E-5	1E-4
63	Europium-152m	W, all compounds	3E+3	6E+3	3E-6	9E-9	4E-5	4E-4
63	Europium-152	W, all compounds	8E+2	2E+1	1E-8	3E-11	1E-5	1E-4
63	Europium-154	W, all compounds	5E+2	2E+1	8E-9	3E-11	7E-6	7E-5
63	Europium-155	W, all compounds	4E+3	9E+1	4E-8	-	5E-5	5E-4
			-	Bone surf	-	-	-	-
			(1E+2)	-	2E-10	-	-	-
63	Europium-156	W, all compounds	6E+2	5E+2	2E-7	6E-10	8E-6	8E-5
63	Europium-157	W, all compounds	2E+3	5E+3	2E-6	7E-9	3E-5	3E-4
63	Europium-158 <sup>2</sup>	W, all compounds	2E+4	6E+4	2E-5	8E-8	3E-4	3E-3
64	Gadolinium-145 <sup>2</sup>	D, all compounds except those given for W	5E+4	2E+5	6E-5	2E-7	-	-
			St wall	-	-	-	6E-4	6E-3
			(5E+4)	-	-	-	6E-4	6E-3
		W, oxides, hydroxides, and fluorides	-	2E+5	7E-5	2E-7	-	-
64	Gadolinium-146	D, see <sup>145</sup> Gd	1E+3	1E+2	5E-8	2E-10	2E-5	2E-4
		W, see <sup>145</sup> Gd	-	3E+2	1E-7	4E-10	-	-
64	Gadolinium-147	D, see <sup>145</sup> Gd	2E+3	4E+3	2E-6	6E-9	3E-5	3E-4
		W, see <sup>145</sup> Gd	-	4E+3	1E-6	5E-9	-	-

Atomic Radio-nuclide No.	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
		Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	Monthly Average Concentration (μCi/ml)
		Oral Ingestion	INHALATION		Air (μCi/ml)	Water (μCi/ml)	
		ALI (μCi)	ALI (μCi)	DAC (μCi/ml)			
64 Gadolinium-148	D, see <sup>145</sup> Gd	1E+1	8E+3	3E-12	-	-	-
		Bone surf (2E+1)	Bone surf (2E+2)	-	2E-14	3E-7	3E-6
	W, see <sup>145</sup> Gd	-	3E-2	1E-11	-	-	-
		-	Bone surf (6E-2)	-	8E-14	-	-
64 Gadolinium-149	D, see <sup>145</sup> Gd	3E+3	2E+3	9E-7	3E-9	4E-5	4E-4
	W, see <sup>145</sup> Gd	-	2E+3	1E-6	3E-9	-	-
64 Gadolinium-151	D, see <sup>145</sup> Gd	6E+3	4E+2	2E-7	-	9E-5	9E-4
		-	Bone surf (6E+2)	-	9E-10	-	-
	W, see <sup>145</sup> Gd	-	1E+3	5E-7	2E-9	-	-
64 Gadolinium-152	D, see <sup>145</sup> Gd	2E+1	1E-2	4E-12	-	-	-
		Bone surf (3E+1)	Bone surf (2E-2)	-	3E-14	4E-7	4E-6
	W, see <sup>145</sup> Gd	-	4E-2	2E-11	-	-	-
		-	Bone surf (8E-2)	-	1E-13	-	-
64 Gadolinium-153	D, see <sup>145</sup> Gd	5E+3	1E+2	6E-8	-	6E-5	6E-4
		-	Bone surf (2E+2)	-	3E-10	-	-
	W, see <sup>145</sup> Gd	-	6E+2	2E-7	8E-10	-	-
64 Gadolinium-159	D, see <sup>145</sup> Gd	3E+3	8E+3	3E-6	1E-8	4E-5	4E-4
	W, see <sup>145</sup> Gd	-	6E+3	2E-6	8E-9	-	-
65 Terbium-147 <sup>2</sup>	W, all compounds	9E+3	3E+4	1E-5	5E-8	1E-4	1E-3
65 Terbium-149	W, all compounds	5E+3	7E+2	3E-7	1E-9	7E-5	7E-4
65 Terbium-150	W, all compounds	5E+3	2E+4	9E-6	3E-8	7E-5	7E-4
65 Terbium-151	W, all compounds	4E+3	9E+3	4E-6	1E-8	5E-5	5E-4
65 Terbium-153	W, all compounds	5E+3	7E+3	3E-6	1E-8	7E-5	7E-4
65 Terbium-154	W, all compounds	2E+3	4E+3	2E-6	6E-9	2E-5	2E-4
65 Terbium-155	W, all compounds	6E+3	8E+3	3E-6	1E-8	8E-5	8E-4
65 Terbium-156m (5.0 h)	W, all compounds	2E+4	3E+4	1E-5	4E-8	2E-4	2E-3
65 Terbium-156m (24.4 h)	W, all compounds	7E+3	8E+3	3E-6	1E-8	1E-4	1E-3
65 Terbium-156	W, all compounds	1E+3	1E+3	6E-7	2E-9	1E-5	1E-4
65 Terbium-157	W, all compounds	5E+4	3E+2	1E-7	-	-	-
		LLI wall (5E+4)	Bone surf (6E+2)	-	8E-10	7E-4	7E-3

Atomic Radio-nuclide No.	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers	
		Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	Monthly Average Concentration ( $\mu\text{Ci/ml}$ )	
		Oral Ingestion ALI ( $\mu\text{Ci}$ )	INHALATION		Air ( $\mu\text{Ci/ml}$ )	Water ( $\mu\text{Ci/ml}$ )		
			ALI ( $\mu\text{Ci}$ )	DAC ( $\mu\text{Ci/ml}$ )				
65	Terbium-158	W, all compounds	1E+3	2E+1	8E-9	3E-11	2E-5	2E-4
65	Terbium-160	W, all compounds	8E+2	2E+2	9E-8	3E-10	1E-5	1E-4
65	Terbium-161	W, all compounds	2E+3	2E+3	7E-7	2E-9	-	-
			LLI wall (2E+3)	-	-	-	3E-5	3E-4
66	Dysprosium-155	W, all compounds	9E+3	3E+4	1E-5	4E-8	1E-4	1E-3
66	Dysprosium-157	W, all compounds	2E+4	6E+4	3E-5	9E-8	3E-4	3E-3
66	Dysprosium-159	W, all compounds	1E+4	2E+3	1E-6	3E-9	2E-4	2E-3
66	Dysprosium-165	W, all compounds	1E+4	5E+4	2E-5	6E-8	2E-4	2E-3
66	Dysprosium-166	W, all compounds	6E+2	7E+2	3E-7	1E-9	-	-
			LLI wall (8E+2)	-	-	-	1E-5	1E-4
67	Holmium-155 <sup>2</sup>	W, all compounds	4E+4	2E+5	6E-5	2E-7	6E-4	6E-3
67	Holmium-157 <sup>2</sup>	W, all compounds	3E+5	1E+6	6E-4	2E-6	4E-3	4E-2
67	Holmium-159 <sup>2</sup>	W, all compounds	2E+5	1E+6	4E-4	1E-6	3E-3	3E-2
67	Holmium-161	W, all compounds	1E+5	4E+5	2E-4	6E-7	1E-3	1E-2
67	Holmium-162m <sup>2</sup>	W, all compounds	5E+4	3E+5	1E-4	4E-7	7E-4	7E-3
67	Holmium-162 <sup>2</sup>	W, all compounds	5E+5	2E+6	1E-3	3E-6	-	-
			St wall (8E+5)	-	-	-	1E-2	1E-1
67	Holmium-164m <sup>2</sup>	W, all compounds	1E+5	3E+5	1E-4	4E-7	1E-3	1E-2
67	Holmium-164 <sup>2</sup>	W, all compounds	2E+5	6E+5	3E-4	9E-7	-	-
			St wall (2E+5)	-	-	-	3E-3	3E-2
67	Holmium-166m	W, all compounds	6E+2	7E+0	3E-9	9E-12	9E-6	9E-5
67	Holmium-166	W, all compounds	9E+2	2E+3	7E-7	2E-9	-	-
			LLI wall (9E+2)	-	-	-	1E-5	1E-4
67	Holmium-167	W, all compounds	2E+4	6E+4	2E-5	8E-8	2E-4	2E-3
68	Erbium-161	W, all compounds	2E+4	6E+4	3E-5	9E-8	2E-4	2E-3
68	Erbium-165	W, all compounds	6E+4	2E+5	8E-5	3E-7	9E-4	9E-3
68	Erbium-169	W, all compounds	3E+3	3E+3	1E-6	4E-9	-	-
			LLI wall (4E+3)	-	-	-	5E-5	5E-4
68	Erbium-171	W, all compounds	4E+3	1E+4	4E-6	1E-8	5E-5	5E-4
68	Erbium-172	W, all compounds	1E+3	1E+3	6E-7	2E-9	-	-
			LLI wall (E+3)	-	-	-	2E-5	2E-4
69	Thulium-162 <sup>2</sup>	W, all compounds	7E+4	3E+5	1E-4	4E-7	-	-
			St wall (7E+4)	-	-	-	1E-3	1E-2
69	Thulium-166	W, all compounds	4E+3	1E+4	6E-6	2E-8	6E-5	6E-4
69	Thulium-167	W, all compounds	2E+3	2E+3	8E-7	3E-9	-	-
			LLI wall (2E+3)	-	-	-	3E-5	3E-4

Atomic Radio-nuclide No.	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers		
		Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	Monthly Average Concentration (μCi/ml)		
		Oral Ingestion	INHALATION		Air (μCi/ml)	Water (μCi/ml)			
		ALI (μCi)	ALI (μCi)	DAC (μCi/ml)					
69	Thulium-170	W, all compounds	8E+2	2E+2	9E-8	3E-10	-	-	
		LLI wall	(1E+3)	-	-	-	1E-5	1E-4	
69	Thulium-171	W, all compounds	1E+4	3E+2	1E-7	-	-	-	
		LLI wall	(1E+4)	Bone surf	(6E+2)	-	8E-10	2E-4	2E-3
69	Thulium-172	W, all compounds	7E+2	1E+3	5E-7	2E-9	-	-	
		LLI wall	(8E+2)	-	-	-	1E-5	1E-4	
69	Thulium-173	W, all compounds	4E+3	1E+4	5E-6	2E-8	6E-5	6E-4	
69	Thulium-175 <sup>2</sup>	W, all compounds	7E+4	3E+5	1E-4	4E-7	-	-	
		St wall	(9E+4)	-	-	-	1E-3	1E-2	
70	Ytterbium-162 <sup>2</sup>	W, all compounds except those given for Y	7E+4	3E+5	1E-4	4E-7	1E-3	1E-2	
		Y, oxides, hydroxides, and fluorides	-	3E+5	1E-4	4E-7	-	-	
70	Ytterbium-166	W, see <sup>162</sup> Yb	1E+3	2E+3	8E-7	3E-9	2E-5	2E-4	
		Y, see <sup>162</sup> Yb	-	2E+3	8E-7	3E-9	-	-	
70	Ytterbium-167 <sup>2</sup>	W, see <sup>162</sup> Yb	3E+5	8E+5	3E-4	1E-6	4E-3	4E-2	
		Y, see <sup>162</sup> Yb	-	7E+5	3E-4	1E-6	-	-	
70	Ytterbium-169	W, see <sup>162</sup> Yb	2E+3	8E+2	4E-7	1E-9	2E-5	2E-4	
		Y, see <sup>162</sup> Yb	-	7E+2	3E-7	1E-9	-	-	
70	Ytterbium-175	W, see <sup>162</sup> Yb	3E+3	4E+3	1E-6	5E-9	-	-	
		LLI wall	(3E+3)	-	-	-	4E-5	4E-4	
		Y, see <sup>162</sup> Yb	-	3E+3	1E-6	5E-9	-	-	
70	Ytterbium-177 <sup>2</sup>	W, see <sup>162</sup> Yb	2E+4	5E+4	2E-5	7E-8	2E-4	2E-3	
		Y, see <sup>162</sup> Yb	-	5E+4	2E-5	6E-8	-	-	
70	Ytterbium-178 <sup>2</sup>	W, see <sup>162</sup> Yb	1E+4	4E+4	2E-5	6E-8	2E-4	2E-3	
		Y, see <sup>162</sup> Yb	-	4E+4	2E-5	5E-8	-	-	
71	Lutetium-169	W, all compounds except those given for Y	3E+3	4E+3	2E-6	6E-9	3E-5	3E-4	
		Y, oxides, hydroxides, and fluorides	-	4E+3	2E-6	6E-9	-	-	
71	Lutetium-170	W, see <sup>169</sup> Lu	1E+3	2E+3	9E-7	3E-9	2E-5	2E-4	
		Y, see <sup>169</sup> Lu	-	2E+3	8E-7	3E-9	-	-	
71	Lutetium-171	W, see <sup>169</sup> Lu	2E+3	2E+3	8E-7	3E-9	3E-5	3E-4	
		Y, see <sup>169</sup> Lu	-	2E+3	8E-7	3E-9	-	-	
71	Lutetium-172	W, see <sup>169</sup> Lu	1E+3	1E+3	5E-7	2E-9	1E-5	1E-4	
		Y, see <sup>169</sup> Lu	-	1E+3	5E-7	2E-9	-	-	

Atomic Radio-nuclide No.	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
		Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	Monthly Average Concentration (μCi/ml)
		Oral Ingestion	INHALATION		Air (μCi/ml)	Water (μCi/ml)	
			ALI (μCi)	ALI (μCi)			
71 Lutetium-173	W, see <sup>169</sup> Lu	5E+3	3E+2	1E-7	-	7E-5	7E-4
			Bone surf				
	Y, see <sup>169</sup> Lu	-	(5E+2)	-	6E-10	-	-
	Y, see <sup>169</sup> Lu	-	3E+2	1E-7	4E-10	-	-
71 Lutetium-174m	W, see <sup>169</sup> Lu	2E+3	2E+2	1E-7	-	-	-
		LLI wall	Bone surf				
		(3E+3)	(3E+2)	-	5E-10	4E-5	4E-4
	Y, see <sup>169</sup> Lu	-	2E+2	9E-8	3E-10	-	-
71 Lutetium-174	W, see <sup>169</sup> Lu	5E+3	1E+2	5E-8	-	7E-5	7E-4
			Bone surf				
		-	(2E+2)	-	3E-10	-	-
	Y, see <sup>169</sup> Lu	-	2E+2	6E-8	2E-10	-	-
71 Lutetium-176m	W, see <sup>169</sup> Lu	8E+3	3E+4	1E-5	3E-8	1E-4	1E-3
	Y, see <sup>169</sup> Lu	-	2E+4	9E-6	3E-8	-	-
71 Lutetium-176	W, see <sup>169</sup> Lu	7E+2	5E+0	2E-9	-	1E-5	1E-4
			Bone surf				
		-	(1E+1)	-	2E-11	-	-
	Y, see <sup>169</sup> Lu	-	8E+0	3E-9	1E-11	-	-
71 Lutetium-177m	W, see <sup>169</sup> Lu	7E+2	1E+2	5E-8	-	1E-5	1E-4
			Bone surf				
		-	(1E+2)	-	2E-10	-	-
	Y, see <sup>169</sup> Lu	-	8E+1	3E-8	1E-10	-	-
71 Lutetium-177	W, see <sup>169</sup> Lu	2E+3	2E+3	9E-7	3E-9	-	-
		LLI wall					
		(3E+3)	-	-	-	4E-5	4E-4
	Y, see <sup>169</sup> Lu	-	2E+3	9E-7	3E-9	-	-
71 Lutetium-178m <sup>2</sup>	W, see <sup>169</sup> Lu	5E+4	2E+5	8E-5	3E-7	-	-
		St wall					
		(6E+4)	-	-	-	8E-4	8E-3
	Y, see <sup>169</sup> Lu	-	2E+5	7E-5	2E-7	-	-
71 Lutetium-178 <sup>2</sup>	W, see <sup>169</sup> Lu	4E+4	1E+5	5E-5	2E-7	-	-
		St wall					
		(4E+4)	-	-	-	6E-4	6E-3
	Y, see <sup>169</sup> Lu	-	1E+5	5E-5	2E-7	-	-
71 Lutetium-179	W, see <sup>169</sup> Lu	6E+3	2E+4	8E-6	3E-8	9E-5	9E-4
	Y, see <sup>169</sup> Lu	-	2E+4	6E-6	3E-8	-	-



Atomic Radio-nuclide No.	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers	
		Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	Monthly Average Concentration (μCi/ml)	
		Oral Ingestion ALI (μCi)	INHALATION ALI (μCi)      DAC (μCi/ml)		Air (μCi/ml)	Water (μCi/ml)		
72	Hafnium-170	D, all compounds except those given for W	3E+3	6E+3	2E-6	8E-9	4E-5	4E-4
		W, oxides, hydroxides, carbides, and nitrates	-	5E+3	2E-6	6E-9	-	-
72	Hafnium-172	D, see <sup>170</sup> Hf	1E+3	9E+0	4E-9	-	2E-5	2E-4
				Bone surf				
			-	(2E+1)	-	3E-11	-	-
		W, see <sup>170</sup> Hf	-	4E+1	2E-8	-	-	-
				Bone surf				
			-	(6E+1)	-	8E-11	-	-
72	Hafnium-173	D, see <sup>170</sup> Hf	5E+3	1E+4	5E-6	2E-8	7E-5	7E-4
		W, see <sup>170</sup> Hf	-	1E+4	5E-6	2E-8	-	-
72	Hafnium-175	D, see <sup>170</sup> Hf	3E+3	9E+2	4E-7	-	4E-5	4E-4
				Bone surf				
			-	(1E+3)	-	1E-9	-	-
		W, see <sup>170</sup> Hf	-	1E+3	5E-7	2E-9	-	-
72	Hafnium-177m <sup>2</sup>	D, see <sup>170</sup> Hf	2E+4	6E+4	2E-5	8E-8	3E-4	3E-3
		W, see <sup>170</sup> Hf	-	9E+4	4E-5	1E-7	-	-
72	Hafnium-178m	D, see <sup>170</sup> Hf	3E+2	1E+0	5E-10	-	3E-6	3E-5
				Bone surf				
			-	(2E+0)	-	3E-12	-	-
		W, see <sup>170</sup> Hf	-	5E+0	2E-9	-	-	-
				Bone surf				
			-	(9E+0)	-	1E-11	-	-
72	Hafnium-179m	D, see <sup>170</sup> Hf	1E+3	3E+2	1E-7	-	1E-5	1E-4
				Bone surf				
			-	(6E+2)	-	8E-10	-	-
		W, see <sup>170</sup> Hf	-	6E+2	3E-7	8E-10	-	-
72	Hafnium-180m	D, see <sup>170</sup> Hf	7E+3	2E+4	9E-6	3E-8	1E-4	1E-3
		W, see <sup>170</sup> Hf	-	3E+4	1E-5	4E-8	-	-
72	Hafnium-181	D, see <sup>170</sup> Hf	1E+3	2E+2	7E-8	-	2E-5	2E-4
				Bone surf				
			-	(4E+2)	-	6E-10	-	-
		W, see <sup>170</sup> Hf	-	4E+2	2E-7	6E-10	-	-
72	Hafnium-182m <sup>2</sup>	D, see <sup>170</sup> Hf	4E+4	9E+4	4E-5	1E-7	5E-4	5E-3
		W, see <sup>170</sup> Hf	-	1E+5	6E-5	2E-7	-	-

Atomic Radio-nuclide No.	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers	
		Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	Monthly Average Concentration (μCi/ml)	
		Oral Ingestion	INHALATION		Air (μCi/ml)	Water (μCi/ml)		
			ALI (μCi)	ALI (μCi)				DAC (μCi/ml)
72	Hafnium-182	D, see <sup>170</sup> Hf	2E+2	8E-1	3E-10	-	-	-
			Bone surf (4E+2)	Bone surf (2E+0)	-	2E-12	5E-6	5E-5
		W, see <sup>170</sup> Hf	-	3E+0	1E-9	-	-	-
			-	Bone surf (7E+0)	-	1E-11	-	-
72	Hafnium-183 <sup>2</sup>	D, see <sup>170</sup> Hf	2E+4	5E+4	2E-5	6E-8	3E-4	3E-3
		W, see <sup>170</sup> Hf	-	6E+4	2E-5	8E-8	-	-
73	Tantalum-172 <sup>2</sup>	W, all compounds except those given for Y	4E+4	1E+5	5E-5	2E-7	5E-4	5E-3
		Y, elemental Ta, oxides, hydroxides, halides, carbides, nitrates, and nitrides	-	1E+5	4E-5	1E-7	-	-
73	Tantalum-173	W, see <sup>172</sup> Ta	7E+3	2E+4	8E-6	3E-8	9E-5	9E-4
		Y, see <sup>172</sup> Ta	-	2E+4	7E-6	2E-8	-	-
73	Tantalum-174 <sup>2</sup>	W, see <sup>172</sup> Ta	3E+4	1E+5	4E-5	1E-7	4E-4	4E-3
		Y, see <sup>172</sup> Ta	-	9E+4	4E-5	1E-7	-	-
73	Tantalum-175	W, see <sup>172</sup> Ta	6E+3	2E+4	7E-6	2E-8	8E-5	8E-4
		Y, see <sup>172</sup> Ta	-	1E+4	6E-6	2E-8	-	-
73	Tantalum-176	W, see <sup>172</sup> Ta	4E+3	1E+4	5E-6	2E-8	5E-5	5E-4
		Y, see <sup>172</sup> Ta	-	1E+4	5E-6	2E-8	-	-
73	Tantalum-177	W, see <sup>172</sup> Ta	1E+4	2E+4	8E-6	3E-8	2E-4	2E-3
		Y, see <sup>172</sup> Ta	-	2E+4	7E-6	2E-8	-	-
73	Tantalum-178	W, see <sup>172</sup> Ta	2E+4	9E+4	4E-5	1E-7	2E-4	2E-3
		Y, see <sup>172</sup> Ta	-	7E+4	3E-5	1E-7	-	-
73	Tantalum-179	W, see <sup>172</sup> Ta	2E+4	5E+3	2E-6	8E-9	3E-4	3E-3
		Y, see <sup>172</sup> Ta	-	9E+2	4E-7	1E-9	-	-
73	Tantalum-180m	W, see <sup>172</sup> Ta	2E+4	7E+4	3E-5	9E-8	3E-4	3E-3
		Y, see <sup>172</sup> Ta	-	6E+4	2E-5	8E-8	-	-
73	Tantalum-180	W, see <sup>172</sup> Ta	1E+3	4E+2	2E-7	6E-10	2E-5	2E-4
		Y, see <sup>172</sup> Ta	-	2E+1	1E-8	3E-11	-	-
73	Tantalum-182m <sup>2</sup>	W, see <sup>172</sup> Ta	2E+5	5E+5	2E-4	8E-7	-	-
		St wall	(2E+5)	-	-	-	3E-3	3E-2
		Y, see <sup>172</sup> Ta	-	4E+5	2E-4	6E-7	-	-
73	Tantalum-182	W, see <sup>172</sup> Ta	8E+2	3E+2	1E-7	5E-10	1E-5	1E-4
		Y, see <sup>172</sup> Ta	-	1E+2	6E-8	2E-10	-	-
73	Tantalum-183	W, see <sup>172</sup> Ta	9E+2	1E+3	5E-7	2E-9	-	-
		LLI wall	(1E+3)	-	-	-	2E-5	2E-4
		Y, see <sup>172</sup> Ta	-	1E+3	4E-7	1E-9	-	-

Atomic Radio-nuclide No.	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
		Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	Monthly Average Concentration (μCi/ml)
		Oral Ingestion	INHALATION		Air (μCi/ml)	Water (μCi/ml)	
			ALI (μCi)	ALI (μCi)			
73 Tantalum-184	W, see <sup>172</sup> Ta	2E+3	5E+3	2E-6	8E-9	3E-5	3E-4
	Y, see <sup>172</sup> Ta	-	5E+3	2E-6	7E-9	-	-
73 Tantalum-185 <sup>2</sup>	W, see <sup>172</sup> Ta	3E+4	7E+4	3E-5	1E-7	4E-4	4E-3
	Y, see <sup>172</sup> Ta	-	6E+4	3E-5	9E-8	-	-
73 Tantalum-186 <sup>2</sup>	W, see <sup>172</sup> Ta	5E+4	2E+5	1E-4	3E-7	-	-
	St wall	(7E+4)	-	-	-	1E-3	1E-2
	Y, see <sup>172</sup> Ta	-	2E+5	9E-5	3E-7	-	-
74 Tungsten-176	D, all compounds	1E+4	5E+4	2E-5	7E-8	1E-4	1E-3
74 Tungsten-177	D, all compounds	2E+4	9E+4	4E-5	1E-7	3E-4	3E-3
74 Tungsten-178	D, all compounds	5E+3	2E+4	8E-6	3E-8	7E-5	7E-4
74 Tungsten-179 <sup>2</sup>	D, all compounds	5E+5	2E+6	7E-4	2E-6	7E-3	7E-2
74 Tungsten-181	D, all compounds	2E+4	3E+4	1E-5	5E-8	2E-4	2E-3
74 Tungsten-185	D, all compounds	2E+3	7E+3	3E-6	9E-9	-	-
	LLI wall	(3E+3)	-	-	-	4E-5	4E-4
74 Tungsten-187	D, all compounds	2E+3	9E+3	4E-6	1E-8	3E-5	3E-4
74 Tungsten-188	D, all compounds	4E+2	1E+3	5E-7	2E-9	-	-
	LLI wall	(5E+2)	-	-	-	7E-6	7E-5
75 Rhenium-177 <sup>2</sup>	D, all compounds except those given for W	9E+4	3E+5	1E-4	4E-7	-	-
	St wall	(1E+5)	-	-	-	2E-3	2E-2
	W, oxides, hydroxides, and nitrates	-	4E+5	1E-4	5E-7	-	-
75 Rhenium-178 <sup>2</sup>	D, see <sup>177</sup> Re	7E+4	3E+5	1E-4	4E-7	-	-
	St wall	(1E+5)	-	-	-	1E-3	1E-2
	W, see <sup>177</sup> Re	-	3E+5	1E-4	4E-7	-	-
75 Rhenium-181	D, see <sup>177</sup> Re	5E+3	9E+3	4E-6	1E-8	7E-5	7E-4
	W, see <sup>177</sup> Re	-	9E+3	4E-6	1E-8	-	-
75 Rhenium-182 (12.7 h)	D, see <sup>177</sup> Re	7E+3	1E+4	5E-6	2E-8	9E-5	9E-4
	W, see <sup>177</sup> Re	-	2E+4	6E-6	2E-8	-	-
75 Rhenium-182 (64.0 h)	D, see <sup>177</sup> Re	1E+3	2E+3	1E-6	3E-9	2E-5	2E-4
	W, see <sup>177</sup> Re	-	2E+3	9E-7	3E-9	-	-
75 Rhenium-184m	D, see <sup>177</sup> Re	2E+3	3E+3	1E-6	4E-9	3E-5	3E-4
	W, see <sup>177</sup> Re	-	4E+2	2E-7	6E-10	-	-
75 Rhenium-184	D, see <sup>177</sup> Re	2E+3	4E+3	1E-6	5E-9	3E-5	3E-4
	W, see <sup>177</sup> Re	-	1E+3	6E-7	2E-9	-	-

Atomic Radio-nuclide No.	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers	
		Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	Monthly Average Concentration (μCi/ml)	
		Oral Ingestion	INHALATION		Air (μCi/ml)	Water (μCi/ml)		
			ALI (μCi)	ALI (μCi)				DAC (μCi/ml)
75 Rhenium-186m	D, see <sup>177</sup> Re	1E+3	2E+3	7E-7	-	-	-	
		St wall (2E+3)	St wall (2E+3)	-	3E-9	2E-5	2E-4	
75 Rhenium-186	W, see <sup>177</sup> Re	-	2E+2	6E-8	2E-10	-	-	
	D, see <sup>177</sup> Re	2E+3	3E+3	1E-6	4E-9	3E-5	3E-4	
75 Rhenium-187	W, see <sup>177</sup> Re	-	2E+3	7E-7	2E-9	-	-	
	D, see <sup>177</sup> Re	6E+5	8E+5	4E-4	-	8E-3	8E-2	
75 Rhenium-188m <sup>2</sup>	D, see <sup>177</sup> Re	St wall (9E+5)	-	1E-6	-	-	-	
		W, see <sup>177</sup> Re	-	1E+5	4E-5	1E-7	-	-
		8E+4	1E+5	6E-5	2E-7	1E-3	1E-2	
75 Rhenium-188	W, see <sup>177</sup> Re	-	1E+5	6E-5	2E-7	-	-	
	D, see <sup>177</sup> Re	2E+3	3E+3	1E-6	4E-9	2E-5	2E-4	
75 Rhenium-189	W, see <sup>177</sup> Re	-	3E+3	1E-6	4E-9	-	-	
	D, see <sup>177</sup> Re	3E+3	5E+3	2E-6	7E-9	4E-5	4E-4	
76 Osmium-180 <sup>2</sup>	W, see <sup>177</sup> Re	-	4E+3	2E-6	6E-9	-	-	
	D, all compounds except those given for W and Y	1E+5	4E+5	2E-4	5E-7	1E-3	1E-2	
	W, halides and nitrates	-	5E+5	2E-4	7E-7	-	-	
76 Osmium-181 <sup>2</sup>	Y, oxides and hydroxides	-	5E+5	2E-4	6E-7	-	-	
	D, see <sup>180</sup> Os	1E+4	4E+4	2E-5	6E-8	2E-4	2E-3	
	W, see <sup>180</sup> Os	-	5E+4	2E-5	6E-8	-	-	
76 Osmium-182	Y, see <sup>180</sup> Os	-	4E+4	2E-5	6E-8	-	-	
	D, see <sup>180</sup> Os	2E+3	6E+3	2E-6	8E-9	3E-5	3E-4	
	W, see <sup>180</sup> Os	-	4E+3	2E-6	6E-9	-	-	
76 Osmium-185	Y, see <sup>180</sup> Os	-	4E+3	2E-6	6E-9	-	-	
	D, see <sup>180</sup> Os	2E+3	5E+2	2E-7	7E-10	3E-5	3E-4	
	W, see <sup>180</sup> Os	-	8E+2	3E-7	1E-9	-	-	
76 Osmium-189m	Y, see <sup>180</sup> Os	-	8E+2	3E-7	1E-9	-	-	
	D, see <sup>180</sup> Os	8E+4	2E+5	1E-4	3E-7	1E-3	1E-2	
	W, see <sup>180</sup> Os	-	2E+5	9E-5	3E-7	-	-	
76 Osmium-191m	Y, see <sup>180</sup> Os	-	2E+5	7E-5	2E-7	-	-	
	D, see <sup>180</sup> Os	1E+4	3E+4	1E-5	4E-8	2E-4	2E-3	
	W, see <sup>180</sup> Os	-	2E+4	8E-6	3E-8	-	-	
76 Osmium-191	Y, see <sup>180</sup> Os	-	2E+4	7E-6	2E-8	-	-	
	D, see <sup>180</sup> Os	2E+3	2E+3	9E-7	3E-9	-	-	
	LLI wall (3E+3)	-	-	-	-	3E-5	3E-4	
76 Osmium-191	W, see <sup>180</sup> Os	-	2E+3	7E-7	2E-9	-	-	
	Y, see <sup>180</sup> Os	-	1E+3	6E-7	2E-9	-	-	

Atomic Radio-nuclide No.	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
		Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	Monthly Average Concentration (μCi/ml)
		Oral Ingestion	INHALATION		Air (μCi/ml)	Water (μCi/ml)	
			ALI (μCi)	ALI (μCi)			
76 Osmium-193	D, see <sup>180</sup> Os	2E+3	5E+3	2E-6	6E-9	-	-
		LLI wall					
		(2E+3)	-	-	-	2E-5	2E-4
76 Osmium-194	D, see <sup>180</sup> Os	-	3E+3	1E-6	4E-9	-	-
		-	3E+3	1E-6	4E-9	-	-
		4E+2	4E+1	2E-8	6E-11	-	-
77 Iridium-182 <sup>2</sup>	D, all compounds except those given for W and Y	4E+4	1E+5	6E-5	2E-7	-	-
		LLI wall					
		(4E+4)	-	-	-	6E-4	6E-3
77 Iridium-184	D, see <sup>182</sup> Ir	-	6E+1	2E-8	8E-11	-	-
		-	8E+0	3E-9	1E-11	-	-
		-	2E+5	6E-5	2E-7	-	-
77 Iridium-185	D, see <sup>182</sup> Ir	-	1E+5	5E-5	2E-7	-	-
		-	1E+5	5E-5	2E-7	-	-
		8E+3	2E+4	1E-5	3E-8	1E-4	1E-3
77 Iridium-186	D, see <sup>182</sup> Ir	-	3E+4	1E-5	5E-8	-	-
		-	3E+4	1E-5	4E-8	-	-
		5E+3	1E+4	5E-6	2E-8	7E-5	7E-4
77 Iridium-187	D, see <sup>182</sup> Ir	-	1E+4	5E-6	2E-8	-	-
		-	1E+4	4E-6	1E-8	-	-
		2E+3	8E+3	3E-6	1E-8	3E-5	3E-4
77 Iridium-188	D, see <sup>182</sup> Ir	-	6E+3	3E-6	9E-9	-	-
		-	6E+3	2E-6	8E-9	-	-
		1E+4	3E+4	1E-5	5E-8	1E-4	1E-3
77 Iridium-189	D, see <sup>182</sup> Ir	-	3E+4	1E-5	4E-8	-	-
		-	3E+4	1E-5	4E-8	-	-
		2E+3	5E+3	2E-6	6E-9	3E-5	3E-4
77 Iridium-190m <sup>2</sup>	D, see <sup>182</sup> Ir	-	4E+3	1E-6	5E-9	-	-
		-	3E+3	1E-6	5E-9	-	-
		5E+3	5E+3	2E-6	7E-9	-	-
77 Iridium-190m <sup>2</sup>	D, see <sup>182</sup> Ir	5E+3	5E+3	2E-6	7E-9	-	-
		LLI wall					
		(5E+3)	-	-	-	7E-5	7E-4
77 Iridium-190m <sup>2</sup>	D, see <sup>182</sup> Ir	-	4E+3	2E-6	5E-9	-	-
		-	4E+3	1E-6	5E-9	-	-
		2E+5	2E+5	8E-5	3E-7	2E-3	2E-2
77 Iridium-190m <sup>2</sup>	D, see <sup>182</sup> Ir	-	2E+5	9E-5	3E-7	-	-
		-	2E+5	8E-5	3E-7	-	-
		2E+5	2E+5	8E-5	3E-7	-	-

Atomic Radio-nuclide No.	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
		Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	Monthly Average Concentration ( $\mu\text{Ci/ml}$ )
		Oral Ingestion ALI ( $\mu\text{Ci}$ )	INHALATION		Air ( $\mu\text{Ci/ml}$ )	Water ( $\mu\text{Ci/ml}$ )	
			ALI ( $\mu\text{Ci}$ )	DAC ( $\mu\text{Ci/ml}$ )			
77 Iridium-190	D, see $^{182}\text{Ir}$	1E+3	9E+2	4E-7	1E-9	1E-5	1E-4
	W, see $^{182}\text{Ir}$	-	1E+3	4E-7	1E-9	-	-
	Y, see $^{182}\text{Ir}$	-	9E+2	4E-7	1E-9	-	-
77 Iridium-192m	D, see $^{182}\text{Ir}$	3E+3	9E+1	4E-8	1E-10	4E-5	4E-4
	W, see $^{182}\text{Ir}$	-	2E+2	9E-8	3E-10	-	-
	Y, see $^{182}\text{Ir}$	-	2E+1	6E-9	2E-11	-	-
77 Iridium-192	D, see $^{182}\text{Ir}$	9E+2	3E+2	1E-7	4E-10	1E-5	1E-4
	W, see $^{182}\text{Ir}$	-	4E+2	2E-7	6E-10	-	-
	Y, see $^{182}\text{Ir}$	-	2E+2	9E-8	3E-10	-	-
77 Iridium-194m	D, see $^{182}\text{Ir}$	6E+2	9E+1	4E-8	1E-10	9E-6	9E-5
	W, see $^{182}\text{Ir}$	-	2E+2	7E-8	2E-10	-	-
	Y, see $^{182}\text{Ir}$	-	1E+2	4E-8	1E-10	-	-
77 Iridium-194	D, see $^{182}\text{Ir}$	1E+3	3E+3	1E-6	4E-9	1E-5	1E-4
	W, see $^{182}\text{Ir}$	-	2E+3	9E-7	3E-9	-	-
	Y, see $^{182}\text{Ir}$	-	2E+3	8E-7	3E-9	-	-
77 Iridium-195m	D, see $^{182}\text{Ir}$	8E+3	2E+4	1E-5	3E-8	1E-4	1E-3
	W, see $^{182}\text{Ir}$	-	3E+4	1E-5	4E-8	-	-
	Y, see $^{182}\text{Ir}$	-	2E+4	9E-6	3E-8	-	-
77 Iridium-195	D, see $^{182}\text{Ir}$	1E+4	4E+4	2E-5	6E-8	2E-4	2E-3
	W, see $^{182}\text{Ir}$	-	5E+4	2E-5	7E-8	-	-
	Y, see $^{182}\text{Ir}$	-	4E+4	2E-5	6E-8	-	-
78 Platinum-186	D, all compounds	1E+4	4E+4	2E-5	5E-8	2E-4	2E-3
78 Platinum-188	D, all compounds	2E+3	2E+3	7E-7	2E-9	2E-5	2E-4
78 Platinum-189	D, all compounds	1E+4	3E+4	1E-5	4E-8	1E-4	1E-3
78 Platinum-191	D, all compounds	4E+3	8E+3	4E-6	1E-8	5E-5	5E-4
78 Platinum-193m	D, all compounds	3E+3	6E+3	3E-6	8E-9	-	-
		LLI wall (3E+4)	-	-	-	4E-5	4E-4
78 Platinum-193	D, all compounds	4E+4	2E+4	1E-5	3E-8	-	-
		LLI wall (5E+4)	-	-	-	6E-4	6E-3
78 Platinum-195m	D, all compounds	2E+3	4E+3	2E-6	6E-9	-	-
		LLI wall (2E+3)	-	-	-	3E-5	3E-4
78 Platinum-197m <sup>2</sup>	D, all compounds	2E+4	4E+4	2E-5	6E-8	2E-4	2E-3
78 Platinum-197	D, all compounds	3E+3	1E+4	4E-6	1E-8	4E-5	4E-4
78 Platinum-199 <sup>2</sup>	D, all compounds	5E+4	1E+5	6E-5	2E-7	7E-4	7E-3
78 Platinum-200	D, all compounds	1E+3	3E+3	1E-6	5E-9	2E-5	2E-4

Atomic Radio-nuclide No.	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
		Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	Monthly Average Concentration (μCi/ml)
		Oral Ingestion	INHALATION		Air (μCi/ml)	Water (μCi/ml)	
			ALI (μCi)	ALI (μCi)			
79 Gold-193	D, all compounds except those given for W and Y	9E+3	3E+4	1E-5	4E-8	1E-4	1E-3
	W, halides and nitrates	-	2E+4	9E-6	3E-8	-	-
	Y, oxides and hydroxides	-	2E+4	8E-6	3E-8	-	-
79 Gold-194	D, see <sup>193</sup> Au	3E+3	8E+3	3E-6	1E-8	4E-5	4E-4
	W, see <sup>193</sup> Au	-	5E+3	2E-6	8E-9	-	-
	Y, see <sup>193</sup> Au	-	5E+3	2E-6	7E-9	-	-
79 Gold-195	D, see <sup>193</sup> Au	5E+3	1E+4	5E-6	2E-8	7E-5	7E-4
	W, see <sup>193</sup> Au	-	1E+3	6E-7	2E-9	-	-
	Y, see <sup>193</sup> Au	-	4E+2	2E-7	6E-10	-	-
79 Gold-198m	D, see <sup>193</sup> Au	1E+3	3E+3	1E-6	4E-9	1E-5	1E-4
	W, see <sup>193</sup> Au	-	1E+3	5E-7	2E-9	-	-
	Y, see <sup>193</sup> Au	-	1E+3	5E-7	2E-9	-	-
79 Gold-198	D, see <sup>193</sup> Au	1E+3	4E+3	2E-6	5E-9	2E-5	2E-4
	W, see <sup>193</sup> Au	-	2E+3	8E-7	3E-9	-	-
	Y, see <sup>193</sup> Au	-	2E+3	7E-7	2E-9	-	-
79 Gold-199	D, see <sup>193</sup> Au	3E+3	9E+3	4E-6	1E-8	-	-
	LLI wall	(3E+3)	-	-	-	4E-5	4E-4
	W, see <sup>193</sup> Au	-	4E+3	2E-6	6E-9	-	-
	Y, see <sup>193</sup> Au	-	4E+3	2E-6	5E-9	-	-
79 Gold-200m	D, see <sup>193</sup> Au	1E+3	4E+3	1E-6	5E-9	2E-5	2E-4
	W, see <sup>193</sup> Au	-	3E+3	1E-6	4E-9	-	-
	Y, see <sup>193</sup> Au	-	2E+4	1E-6	3E-9	-	-
79 Gold-200 <sup>2</sup>	D, see <sup>193</sup> Au	3E+4	6E+4	3E-5	9E-8	4E-4	4E-3
	W, see <sup>193</sup> Au	-	8E+4	3E-5	1E-7	-	-
	Y, see <sup>193</sup> Au	-	7E+4	3E-5	1E-7	-	-
79 Gold-201 <sup>2</sup>	D, see <sup>193</sup> Au	7E+4	2E+5	9E-5	3E-7	-	-
	St wall	(9E+4)	-	-	-	1E-3	1E-2
	W, see <sup>193</sup> Au	-	2E+5	1E-4	3E-7	-	-
	Y, see <sup>193</sup> Au	-	2E+5	9E-5	3E-7	-	-
80 Mercury-193m	Vapor	-	8E+3	4E-6	1E-8	-	-
	Organic D	4E+3	1E+4	5E-6	2E-8	6E-5	6E-4
	D, sulfates	3E+3	9E+3	4E-6	1E-8	4E-5	4E-4
	W, oxides, hydroxides, halides, nitrates, and sulfides	-	8E+3	3E-6	1E-8	-	-
80 Mercury-193	Vapor	-	3E+4	1E-5	4E-8	-	-
	Organic D	2E+4	6E+4	3E-5	9E-8	3E-4	3E-3
	D, see <sup>193m</sup> Hg	2E+4	4E+4	2E-5	6E-8	2E-4	2E-3
	W, see <sup>193m</sup> Hg	-	4E+4	2E-5	6E-8	-	-

Atomic Radio-nuclide No.	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers	
		Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	Monthly Average Concentration ( $\mu\text{Ci/ml}$ )	
		Oral Ingestion	INHALATION		Air ( $\mu\text{Ci/ml}$ )	Water ( $\mu\text{Ci/ml}$ )		
		ALI ( $\mu\text{Ci}$ )	ALI ( $\mu\text{Ci}$ )	DAC ( $\mu\text{Ci/ml}$ )				
80	Mercury-194	Vapor	-	3E+1	1E-8	4E-11	-	-
		Organic D	2E+1	3E+1	1E-8	4E-11	2E-7	2E-6
		D, see $^{193\text{m}}\text{Hg}$	8E+2	4E+1	2E-8	6E-11	1E-5	1E-4
		W, see $^{193\text{m}}\text{Hg}$	-	1E+2	5E-8	2E-10	-	-
80	Mercury-195m	Vapor	-	4E+3	2E-6	6E-9	-	-
		Organic D	3E+3	6E+3	3E-6	8E-9	4E-5	4E-4
		D, see $^{193\text{m}}\text{Hg}$	2E+3	5E+3	2E-6	7E-9	3E-5	3E-4
		W, see $^{193\text{m}}\text{Hg}$	-	4E+3	2E-6	5E-9	-	-
80	Mercury-195	Vapor	-	3E+4	1E-5	4E-8	-	-
		Organic D	2E+4	5E+4	2E-5	6E-8	2E-4	2E-3
		D, see $^{193\text{m}}\text{Hg}$	1E+4	4E+4	1E-5	5E-8	2E-4	2E-3
		W, see $^{193\text{m}}\text{Hg}$	-	3E+4	1E-5	5E-8	-	-
80	Mercury-197m	Vapor	-	5E+3	2E-6	7E-9	-	-
		Organic D	4E+3	9E+3	4E-6	1E-8	5E-5	5E-4
		D, see $^{193\text{m}}\text{Hg}$	3E+3	7E+3	3E-6	1E-8	4E-5	4E-4
		W, see $^{193\text{m}}\text{Hg}$	-	5E+3	2E-6	7E-9	-	-
80	Mercury-197	Vapor	-	8E+3	4E-6	1E-8	-	-
		Organic D	7E+3	1E+4	6E-6	2E-8	9E-5	9E-4
		D, see $^{193\text{m}}\text{Hg}$	6E+3	1E+4	5E-6	2E-8	8E-5	8E-4
		W, see $^{193\text{m}}\text{Hg}$	-	9E+3	4E-6	1E-8	-	-
80	Mercury-199m <sup>2</sup>	Vapor	-	8E+4	3E-5	1E-7	-	-
		Organic D	6E+4	2E+5	7E-5	2E-7	-	-
		St wall	(1E+5)	-	-	-	1E-3	1E-2
		D, see $^{193\text{m}}\text{Hg}$	6E+4	1E+5	6E-5	2E-7	8E-4	8E-3
		W, see $^{193\text{m}}\text{Hg}$	-	2E+5	7E-5	2E-7	-	-
80	Mercury-203	Vapor	-	8E+2	4E-7	1E-9	-	-
		Organic D	5E+2	8E+2	3E-7	1E-9	7E-6	7E-5
		D, see $^{193\text{m}}\text{Hg}$	2E+3	1E+3	5E-7	2E-9	3E-5	3E-4
		W, see $^{193\text{m}}\text{Hg}$	-	1E+3	5E-7	2E-9	-	-
81	Thallium-194m <sup>2</sup>	D, all compounds	5E+4	2E+5	6E-5	2E-7	-	-
		St wall	(7E+4)	-	-	-	1E-3	1E-2
81	Thallium-194 <sup>2</sup>	D, all compounds	3E+5	6E+5	2E-4	8E-7	-	-
		St wall	(3E+5)	-	-	-	4E-3	4E-2
81	Thallium-195 <sup>2</sup>	D, all compounds	6E+4	1E+5	5E-5	2E-7	9E-4	9E-3
81	Thallium-197	D, all compounds	7E+4	1E+5	5E-5	2E-7	1E-3	1E-2
81	Thallium-198m <sup>2</sup>	D, all compounds	3E+4	5E+4	2E-5	8E-8	4E-4	4E-3
81	Thallium-198	D, all compounds	2E+4	3E+4	1E-5	5E-8	3E-4	3E-3
81	Thallium-199	D, all compounds	6E+4	8E+4	4E-5	1E-7	9E-4	9E-3
81	Thallium-200	D, all compounds	8E+3	1E+4	5E-6	2E-8	1E-4	1E-3
81	Thallium-201	D, all compounds	2E+4	2E+4	9E-6	3E-8	2E-4	2E-3
81	Thallium-202	D, all compounds	4E+3	5E+3	2E-6	7E-9	5E-5	5E-4



Atomic Radio-nuclide No.	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers	
		Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	Monthly Average Concentration ( $\mu\text{Ci/ml}$ )	
		Oral Ingestion	INHALATION		Air ( $\mu\text{Ci/ml}$ )	Water ( $\mu\text{Ci/ml}$ )		
		ALI ( $\mu\text{Ci}$ )	ALI ( $\mu\text{Ci}$ )	DAC ( $\mu\text{Ci/ml}$ )				
81	Thallium-204	D, all compounds	2E+3	2E+3	9E-7	3E-9	2E-5	2E-4
82	Lead-195m <sup>2</sup>	D, all compounds	6E+4	2E+5	8E-5	3E-7	8E-4	8E-3
82	Lead-198	D, all compounds	3E+4	6E+4	3E-5	9E-8	4E-4	4E-3
82	Lead-199 <sup>2</sup>	D, all compounds	2E+4	7E+4	3E-5	1E-7	3E-4	3E-3
82	Lead-200	D, all compounds	3E+3	6E+3	3E-6	9E-9	4E-5	4E-4
82	Lead-201	D, all compounds	7E+3	2E+4	8E-6	3E-8	1E-4	1E-3
82	Lead-202m	D, all compounds	9E+3	3E+4	1E-5	4E-8	1E-4	1E-3
82	Lead-202	D, all compounds	1E+2	5E+1	2E-8	7E-11	2E-6	2E-5
82	Lead-203	D, all compounds	5E+3	9E+3	4E-6	1E-8	7E-5	7E-4
82	Lead-205	D, all compounds	4E+3	1E+3	6E-7	2E-9	5E-5	5E-4
82	Lead-209	D, all compounds	2E+4	6E+4	2E-5	8E-8	3E-4	3E-3
82	Lead-210	D, all compounds	6E-1 Bone surf	2E-1 Bone surf	1E-10	-	-	-
			(1E+0)	(4E-1)	-	6E-13	1E-8	1E-7
82	Lead-211 <sup>2</sup>	D, all compounds	1E+4	6E+2	3E-7	9E-10	2E-4	2E-3
82	Lead-212	D, all compounds	8E+1 Bone surf	3E+1	1E-8	5E-11	-	-
			(1E+2)	-	-	-	2E-6	2E-5
82	Lead-214 <sup>2</sup>	D, all compounds	9E+3	8E+2	3E-7	1E-9	1E-4	1E-3
83	Bismuth-200 <sup>2</sup>	D, nitrates	3E+4	8E+4	4E-5	1E-7	4E-4	4E-3
		W, all other compounds	-	1E+5	4E-5	1E-7	-	-
83	Bismuth-201 <sup>2</sup>	D, see <sup>200</sup> Bi	1E+4	3E+4	1E-5	4E-8	2E-4	2E-3
		W, see <sup>200</sup> Bi	-	4E+4	2E-5	5E-8	-	-
83	Bismuth-202 <sup>2</sup>	D, see <sup>200</sup> Bi	1E+4	4E+4	2E-5	6E-8	2E-4	2E-3
		W, see <sup>200</sup> Bi	-	8E+4	3E-5	1E-7	-	-
83	Bismuth-203	D, see <sup>200</sup> Bi	2E+3	7E+3	3E-6	9E-9	3E-5	3E-4
		W, see <sup>200</sup> Bi	-	6E+3	3E-6	9E-9	-	-
83	Bismuth-205	D, see <sup>200</sup> Bi	1E+3	3E+3	1E-6	3E-9	2E-5	2E-4
		W, see <sup>200</sup> Bi	-	1E+3	5E-7	2E-9	-	-
83	Bismuth-206	D, see <sup>200</sup> Bi	6E+2	1E+3	6E-7	2E-9	9E-6	9E-5
		W, see <sup>200</sup> Bi	-	9E+2	4E-7	1E-9	-	-
83	Bismuth-207	D, see <sup>200</sup> Bi	1E+3	2E+3	7E-7	2E-9	1E-5	1E-4
		W, see <sup>200</sup> Bi	-	4E+2	1E-7	5E-10	-	-
83	Bismuth-210m	D, see <sup>200</sup> Bi	4E+1	5E+0	2E-9	-	-	-
		Kidneys	Kidneys					
			(6E+1)	(6E+0)	-	9E-12	8E-7	8E-6
		W, see <sup>200</sup> Bi	-	7E-1	3E-10	9E-13	-	-
83	Bismuth-210	D, see <sup>200</sup> Bi	8E+2	2E+2	1E-7	-	1E-5	1E-4
				Kidneys				
			-	(4E+2)	-	5E-10	-	-
		W, see <sup>200</sup> Bi	-	3E+1	1E-8	4E-11	-	-

Atomic Radio-nuclide No.	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
		Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	Monthly Average Concentration ( $\mu\text{Ci/ml}$ )
		Oral Ingestion	INHALATION		Air ( $\mu\text{Ci/ml}$ )	Water ( $\mu\text{Ci/ml}$ )	
			ALI ( $\mu\text{Ci}$ )	ALI ( $\mu\text{Ci}$ )			
83 Bismuth-212 <sup>2</sup>	D, see <sup>200</sup> Bi	5E+3	2E+2	1E-7	3E-10	7E-5	7E-4
	W, see <sup>200</sup> Bi	-	3E+2	1E-7	4E-10	-	-
83 Bismuth-213 <sup>2</sup>	D, see <sup>200</sup> Bi	7E+3	3E+2	1E-7	4E-10	1E-4	1E-3
	W, see <sup>200</sup> Bi	-	4E+2	1E-7	5E-10	-	-
83 Bismuth-214 <sup>2</sup>	D, see <sup>200</sup> Bi	2E+4	8E+2	3E-7	1E-9	-	-
	St wall	(2E+4)	-	-	-	3E-4	3E-3
84 Polonium-203 <sup>2</sup>	W, see <sup>200</sup> Bi	-	9E-2	4E-7	1E-9	-	-
	D, all compounds except those given for W	3E+4	6E+4	3E-5	9E-8	3E-4	3E-3
84 Polonium-205 <sup>2</sup>	W, oxides, hydroxides, and nitrates	-	9E+4	4E-5	1E-7	-	-
	D, see <sup>203</sup> Po	2E+4	4E+4	2E-5	5E-8	3E-4	3E-3
84 Polonium-207	W, see <sup>203</sup> Po	-	7E+4	3E-5	1E-7	-	-
	D, see <sup>203</sup> Po	8E+3	3E+4	1E-5	3E-8	1E-4	1E-3
84 Polonium-210	W, see <sup>203</sup> Po	-	3E+4	1E-5	4E-8	-	-
	D, see <sup>203</sup> Po	3E+0	6E-1	3E-10	9E-13	4E-8	4E-7
85 Astatine-207 <sup>2</sup>	W, see <sup>203</sup> Po	-	6E-1	3E-10	9E-13	-	-
	D, halides	6E+3	3E+3	1E-6	4E-9	8E-5	8E-4
85 Astatine-211	W	-	2E+3	9E-7	3E-9	-	-
	D, halides	1E+2	8E+1	3E-8	1E-10	2E-6	2E-5
86 Radon-220	W	-	5E+1	2E-8	8E-11	-	-
	With daughters removed	-	2E+4	7E-6	2E-8	-	-
86 Radon-222	With daughters present	-	2E+1	9E-9	3E-11	-	-
			(or 12 working level months)	(or 1.0 working level)			
87 Francium-222 <sup>2</sup>	With daughters removed	-	1E+4	4E-6	1E-8	-	-
	With daughters present	-	1E+2	3E-8	1E-10	-	-
87 Francium-223 <sup>2</sup>			(or 4 working level months)	(or 0.33 working level)			
	D, all compounds	2E+3	5E+2	2E-7	6E-10	3E-5	3E-4
87 Francium-223 <sup>2</sup>	D, all compounds	6E+2	8E+2	3E-7	1E-9	8E-6	8E-5
88 Radium-223	W, all compounds	5E+0	7E-1	3E-10	9E-13	-	-
	Bone surf	(9E+0)	-	-	-	1E-7	1E-6

Atomic Radio-nuclide No.	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
		Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	Monthly Average Concentration ( $\mu\text{Ci/ml}$ )
		Oral Ingestion	INHALATION		Air ( $\mu\text{Ci/ml}$ )	Water ( $\mu\text{Ci/ml}$ )	
		ALI ( $\mu\text{Ci}$ )	ALI ( $\mu\text{Ci}$ )	DAC ( $\mu\text{Ci/ml}$ )			
88 Radium-224	W, all compounds	8E+0	2E+0	7E-10	2E-12	-	-
		Bone surf (2E+1)	-	-	-	2E-7	2E-6
88 Radium-225	W, all compounds	8E+0	7E-1	3E-10	9E-13	-	-
		Bone surf (2E+1)	-	-	-	2E-7	2E-6
88 Radium-226	W, all compounds	2E+0	6E-1	3E-10	9E-13	-	-
		Bone surf (5E+0)	-	-	-	6E-8	6E-7
88 Radium-227 <sup>2</sup>	W, all compounds	2E+4	1E+4	6E-6	-	-	-
		Bone surf (2E+4)	Bone surf (2E+4)	-	3E-8	3E-4	3E-3
88 Radium-228	W, all compounds	2E+0	1E+0	5E-10	2E-12	-	-
		Bone surf (4E+0)	-	-	-	6E-8	6E-7
89 Actinium-224	D, all compounds except those given for W and Y	2E+3 LLI wall	3E+1 Bone surf	1E-8	-	-	-
		(2E+3)	(4E+1)	-	5E-11	3E-5	3E-4
	W, halides and nitrates	-	5E+1	2E-8	7E-11	-	-
	Y, oxides and hydroxides	-	5E+1	2E-8	6E-11	-	-
89 Actinium-225	D, see <sup>224</sup> Ac	5E+1 LLI wall	3E-1 Bone surf	1E-10	-	-	-
		(5E+1)	(5E-1)	-	7E-13	7E-7	7E-6
	W, see <sup>224</sup> Ac	-	6E-1	3E-10	9E-13	-	-
	Y, see <sup>224</sup> Ac	-	6E-1	3E-10	9E-13	-	-
89 Actinium-226	D, see <sup>224</sup> Ac	1E+2 LLI wall	3E+0 Bone surf	1E-9	-	-	-
		(1E+2)	(4E+0)	-	5E-12	2E-6	2E-5
	W, see <sup>224</sup> Ac	-	5E+0	2E-9	7E-12	-	-
	Y, see <sup>224</sup> Ac	-	5E+0	2E-9	6E-12	-	-

Atomic Radio-nuclide No.	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
		Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	Monthly Average Concentration (μCi/ml)
		Oral Ingestion ALI (μCi)	INHALATION ALI (μCi)      DAC (μCi/ml)		Air (μCi/ml)	Water (μCi/ml)	
89 Actinium-227	D, see <sup>224</sup> Ac	2E-1 Bone surf (4E-1)	4E-4 Bone surf (8E-4)	2E-13 - 7E-13	- 1E-15	- 5E-9	- 5E-8
	W, see <sup>224</sup> Ac	-	2E-3 Bone surf (3E-3)	-	4E-15	-	-
	Y, see <sup>224</sup> Ac	-	4E-3	2E-12	6E-15	-	-
89 Actinium-228	D, see <sup>224</sup> Ac	2E+3	9E+0 Bone surf (2E+1)	4E-9 - 2E-8	- 2E-11	3E-5 -	3E-4 -
	W, see <sup>224</sup> Ac	-	4E+1 Bone surf (6E+1)	2E-8	-	-	-
	Y, see <sup>224</sup> Ac	-	4E+1	2E-8	6E-11	-	-
90 Thorium-226 <sup>2</sup>	W, all compounds except those given for Y	5E+3 St wall (5E+3)	2E+2 -	6E-8 -	2E-10 -	- 7E-5	- 7E-4
	Y, oxides and hydroxides	-	1E+2	6E-8	2E-10	-	-
90 Thorium-227	W, see <sup>226</sup> Th	1E+2	3E-1	1E-10	5E-13	2E-6	2E-5
	Y, see <sup>226</sup> Th	-	3E-1	1E-10	5E-13	-	-
90 Thorium-228	W, see <sup>226</sup> Th	6E+0 Bone surf (1E+1)	1E-2 Bone surf (2E-2)	4E-12 -	- 3E-14	- 2E-7	- 2E-6
	Y, see <sup>226</sup> Th	-	2E-2	7E-12	2E-14	-	-
90 Thorium-229	W, see <sup>226</sup> Th	6E-1 Bone surf (1E+0)	9E-4 Bone surf (2E-3)	4E-13 -	- 3E-15	- 2E-8	- 2E-7
	Y, see <sup>226</sup> Th	-	2E-3 Bone surf (3E-3)	1E-12	-	-	-
90 Thorium-230	W, see <sup>226</sup> Th	4E+0 Bone surf (9E+0)	6E-3 Bone surf (2E-2)	3E-12 -	- 2E-14	- 1E-7	- 1E-6
	Y, see <sup>226</sup> Th	-	2E-2 Bone surf (2E-2)	6E-12	-	-	-
90 Thorium-231	W, see <sup>226</sup> Th	4E+3	6E+3	3E-6	9E-9	5E-5	5E-4
	Y, see <sup>226</sup> Th	-	6E+3	3E-6	9E-9	-	-

Atomic Radio-nuclide No.	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers	
		Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	Monthly Average Concentration ( $\mu\text{Ci/ml}$ )	
		Oral Ingestion ALI ( $\mu\text{Ci}$ )	INHALATION ALI ( $\mu\text{Ci}$ )      DAC ( $\mu\text{Ci/ml}$ )		Air ( $\mu\text{Ci/ml}$ )	Water ( $\mu\text{Ci/ml}$ )		
90	Thorium-232	W, see <sup>226</sup> Th	7E-1	1E-3	5E-13	-	-	-
			Bone surf (2E+0)	Bone surf (3E-3)	-	4E-15	3E-8	3E-7
		Y, see <sup>226</sup> Th	-	3E-3	1E-12	-	-	-
			-	Bone surf (4E-3)	-	6E-15	-	-
90	Thorium-234	W, see <sup>226</sup> Th	3E+2	2E+2	8E-8	3E-10	-	-
			LLI wall (4E+2)	-	-	-	5E-6	5E-5
		Y, see <sup>226</sup> Th	-	2E+2	6E-8	2E-10	-	-
91	Protactinium-227 <sup>2</sup>	W, all compounds except those given for Y	4E+3	1E+2	5E-8	2E-10	5E-5	5E-4
		Y, oxides and hydroxides	-	1E+2	4E-8	1E-10	-	-
91	Protactinium-228	W, see <sup>227</sup> Pa	1E+3	1E+1	5E-9	-	2E-5	2E-4
			-	Bone surf (2E+1)	-	3E-11	-	-
		Y, see <sup>227</sup> Pa	-	1E+1	5E-9	2E-11	-	-
91	Protactinium-230	W, see <sup>227</sup> Pa	6E+2	5E+0	2E-9	7E-12	-	-
			Bone surf (9E+2)	-	-	-	1E-5	1E-4
		Y, see <sup>227</sup> Pa	-	4E+0	1E-9	5E-12	-	-
91	Protactinium-231	W, see <sup>227</sup> Pa	2E-1	2E-3	6E-13	-	-	-
			Bone surf (5E-1)	Bone surf (4E-3)	-	6E-15	6E-9	6E-8
		Y, see <sup>227</sup> Pa	-	4E-3	2E-12	-	-	-
			-	Bone surf (6E-3)	-	8E-15	-	-
91	Protactinium-232	W, see <sup>227</sup> Pa	1E+3	2E+1	9E-9	-	2E-5	2E-4
			-	Bone surf (6E+1)	-	8E-11	-	-
		Y, see <sup>227</sup> Pa	-	6E+1	2E-8	-	-	-
			-	Bone surf (7E+1)	-	1E-10	-	-
91	Protactinium-233	W, see <sup>227</sup> Pa	1E+3	7E+2	3E-7	1E-9	-	-
			LLI wall (2E+3)	-	-	-	E-5	2E-4
		Y, see <sup>227</sup> Pa	-	6E+2	2E-7	8E-10	-	-

Atomic Radio-nuclide No.	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers	
		Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	Monthly Average Concentration (µCi/ml)	
		Oral Ingestion ALI (µCi)	INHALATION ALI (µCi) DAC (µCi/ml)		Air (µCi/ml)	Water (µCi/ml)		
91	Protactinium-234	W, see <sup>227</sup> Pa	2E+3	8E+3	3E-6	1E-8	3E-5	3E-4
		Y, see <sup>227</sup> Pa	-	7E+3	3E-6	9E-9	-	-
92	Uranium-230	D, UF, UOF, UO(NO)	4E+0	4E-1	2E-10	-	-	-
		Bone surf	(6E+0)	(6E-1)	-	8E-13	8E-8	8E-7
		W, UO, UF, UCI	-	4E-1	1E-10	5E-13	-	-
		Y, UO, UO	-	3E-1	1E-10	4E-13	-	-
92	Uranium-231	D, see <sup>230</sup> U	5E+3	8E+3	3E-6	1E-8	-	-
		LLI wall	(4E+3)	-	-	-	6E-5	6E-4
		W, see <sup>230</sup> U	-	6E+3	2E-6	8E-9	-	-
		Y, see <sup>230</sup> U	-	5E+3	2E-6	6E-9	-	-
92	Uranium-232	D, see <sup>230</sup> U	2E+0	2E-1	9E-11	-	-	-
		Bone surf	(4E+0)	(4E-1)	-	6E-13	6E-8	6E-7
		W, see <sup>230</sup> U	-	4E-1	2E-10	5E-13	-	-
		Y, see <sup>230</sup> U	-	8E-3	3E-12	1E-14	-	-
92	Uranium-233	D, see <sup>230</sup> U	1E+1	1E+0	5E-10	-	-	-
		Bone surf	(2E+1)	(2E+0)	-	3E-12	3E-7	3E-6
		W, see <sup>230</sup> U	-	7E-1	3E-10	1E-12	-	-
		Y, see <sup>230</sup> U	-	4E-2	2E-11	5E-14	-	-
92	Uranium-234 <sup>3</sup>	D, see <sup>230</sup> U	1E+1	1E+0	5E-10	-	-	-
		Bone surf	(2E+1)	(2E+0)	-	3E-12	3E-7	3E-6
		W, see <sup>230</sup> U	-	7E-1	3E-10	1E-12	-	-
		Y, see <sup>230</sup> U	-	4E-2	2E-11	5E-14	-	-
92	Uranium-235 <sup>3</sup>	D, see <sup>230</sup> U	1E+1	1E+0	6E-10	-	-	-
		Bone surf	(2E+1)	(2E+0)	-	3E-12	3E-7	3E-6
		W, see <sup>230</sup> U	-	8E-1	3E-10	1E-12	-	-
		Y, see <sup>230</sup> U	-	4E-2	2E-11	6E-14	-	-
92	Uranium-236	D, see <sup>230</sup> U	1E+1	1E+0	5E-10	-	-	-
		Bone surf	(2E+1)	(2E+0)	-	3E-12	3E-7	3E-6
		W, see <sup>230</sup> U	-	8E-1	3E-10	1E-12	-	-
		Y, see <sup>230</sup> U	-	4E-2	2E-11	6E-14	-	-

Atomic Radio-nuclide No.	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
		Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	Monthly Average Concentration (μCi/ml)
		Oral Ingestion	INHALATION		Air (μCi/ml)	Water (μCi/ml)	
			ALI (μCi)	ALI (μCi)			
92 Uranium-237	D, see <sup>230</sup> U	2E+3 LLI wall	3E+3	1E-6	4E-9	-	-
		(2E+3)	-	-	-	3E-5	3E-4
	W, see <sup>230</sup> U	-	2E+3	7E-7	2E-9	-	-
	Y, see <sup>230</sup> U	-	2E+3	6E-7	2E-9	-	-
92 Uranium-238 <sup>3</sup>	D, see <sup>230</sup> U	1E+1 Bone surf	1E+0 Bone surf	6E-10	-	-	-
		(2E+1)	(2E+0)	-	3E-12	3E-7	3E-6
	W, see <sup>230</sup> U	-	8E-1	3E-10	1E-12	-	-
	Y, see <sup>230</sup> U	-	4E-2	2E-11	6E-14	-	-
92 Uranium-239 <sup>2</sup>	D, see <sup>230</sup> U	7E+4	2E+5	8E-5	3E-7	9E-4	9E-3
		W, see <sup>230</sup> U	-	2E+5	7E-5	2E-7	-
	Y, see <sup>230</sup> U	-	2E+5	6E-5	2E-7	-	-
92 Uranium-240	D, see <sup>230</sup> U	1E+3	4E+3	2E-6	5E-9	2E-5	2E-4
		W, see <sup>230</sup> U	-	3E+3	1E-6	4E-9	-
	Y, see <sup>230</sup> U	-	2E+3	1E-6	3E-9	-	-
92 Uranium-natural <sup>3</sup>	D, see <sup>230</sup> U	1E+1 Bone surf	1E+0 Bone surf	5E-10	-	-	-
		(2E+1)	(2E+0)	-	3E-12	3E-7	3E-6
	W, see <sup>230</sup> U	-	8E-1	3E-10	9E-13	-	-
	Y, see <sup>230</sup> U	-	5E-2	2E-11	9E-14	-	-
93 Neptunium-232 <sup>2</sup>	W, all compounds	1E+5	2E+3 Bone surf	7E-7	-	2E-3	2E-2
		-	(5E+2)	-	6E-9	-	-
93 Neptunium-233 <sup>2</sup>	W, all compounds	8E+5	3E+6	1E-3	4E-6	1E-2	1E-1
93 Neptunium-234	W, all compounds	2E+3	3E+3	1E-6	4E-9	3E-5	3E-4
93 Neptunium-235	W, all compounds	2E+4 LLI wall	8E+2 Bone surf	3E-7	-	-	-
		(2E+4)	(1E+3)	-	2E-9	3E-4	3E-3
93 Neptunium-236 (1.15E+5 y)	W, all compounds	3E+0 Bone surf	2E-2 Bone surf	9E-12	-	-	-
		(6E+0)	(5E-2)	-	8E-14	9E-8	9E-7
93 Neptunium-236 (22.5 h)	W, all compounds	3E+3 Bone surf	3E+1 Bone surf	1E-8	-	-	-
		(4E+3)	(7E+1)	-	1E-10	5E-5	5E-4
93 Neptunium-237	W, all compounds	5E-1 Bone surf	4E-3 Bone surf	2E-12	-	-	-
		(1E+0)	(1E-2)	-	1E-14	2E-8	2E-7
93 Neptunium-238	W, all compounds	1E+3	6E+1 Bone surf	3E-8	-	2E-5	2E-4
		-	(2E+2)	-	2E-10	-	-

Atomic Radio-nuclide No.	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers	
		Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	Monthly Average Concentration (μCi/ml)	
		Oral Ingestion ALI (μCi)	INHALATION ALI (μCi)      DAC (μCi/ml)		Air (μCi/ml)	Water (μCi/ml)		
93	Neptunium-239	W, all compounds	2E+3 LLI wall (2E+3)	2E+3 -	9E-7 -	3E-9 -	- 2E-5 2E-4	- 2E-4
93	Neptunium-240 <sup>2</sup>	W, all compounds	2E+4	8E+4	3E-5	1E-7	3E-4	3E-3
94	Plutonium-234	W, all compounds except PuO	8E+3	2E+2	9E-8	3E-10	1E-4	1E-3
		Y, PuO	-	2E+2	8E-8	3E-10	-	-
94	Plutonium-235 <sup>2</sup>	W, see <sup>234</sup> Pu	9E+5	3E+6	1E-3	4E-6	1E-2	1E-1
		Y, see <sup>234</sup> Pu	-	3E+6	1E-3	3E-6	-	-
94	Plutonium-236	W, see <sup>234</sup> Pu	2E+0 Bone surf (4E+0)	2E-2 Bone surf (4E-2)	8E-12 -	- 5E-14	- 6E-8	- 6E-7
		Y, see <sup>234</sup> Pu	-	4E-2	2E-11	6E-14	-	-
94	Plutonium-237	W, see <sup>234</sup> Pu	1E+4	3E+3	1E-6	5E-9	2E-4	2E-3
		Y, see <sup>234</sup> Pu	-	3E+3	1E-6	4E-9	-	-
94	Plutonium-238	W, see <sup>234</sup> Pu	9E-1 Bone surf (2E+0)	7E-3 Bone surf (1E-2)	3E-12 -	- 2E-14	- 2E-8	- 2E-7
		Y, see <sup>234</sup> Pu	-	2E-2	8E-12	2E-14	-	-
94	Plutonium-239	W, see <sup>234</sup> Pu	8E-1 Bone surf (1E+0)	6E-3 Bone surf (1E-2)	3E-12 -	- 2E-14	- 2E-8	- 2E-7
		Y, see <sup>234</sup> Pu	-	2E-2 Bone surf (2E-2)	7E-12 -	- 2E-14	- -	- -
94	Plutonium-240	W, see <sup>234</sup> Pu	8E-1 Bone surf (1E+0)	6E-3 Bone surf (1E-2)	3E-12 -	- 2E-14	- 2E-8	- 2E-7
		Y, see <sup>234</sup> Pu	-	2E-2 Bone surf (2E-2)	7E-12 -	- 2E-14	- -	- -
94	Plutonium-241	W, see <sup>234</sup> Pu	4E+1 Bone surf (7E+1)	3E-1 Bone surf (6E-1)	1E-10 -	- 8E-13	- 1E-6	- 1E-5
		Y, see <sup>234</sup> Pu	-	8E-1 Bone surf (1E+0)	3E-10 -	- 1E-12	- -	- -



Atomic Radio-nuclide No.	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
		Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	Monthly Average Concentration (μCi/ml)
		Oral Ingestion	INHALATION		Air (μCi/ml)	Water (μCi/ml)	
		ALI (μCi)	ALI (μCi)	DAC (μCi/ml)			
94 Plutonium-242	W, see <sup>234</sup> Pu	8E-1	7E-3	3E-12	-	-	-
		Bone surf (1E+0)	Bone surf (1E-2)	-	2E-14	2E-8	2E-7
	Y, see <sup>234</sup> Pu	-	2E-2 Bone surf (2E-2)	7E-12	-	-	-
94 Plutonium-243	W, see <sup>234</sup> Pu	2E+4	4E+4	2E-5	5E-8	2E-4	2E-3
	Y, see <sup>234</sup> Pu	-	4E+4	2E-5	5E-8	-	-
94 Plutonium-244	W, see <sup>234</sup> Pu	8E-1	7E-3	3E-12	-	-	-
		Bone surf (2E+0)	Bone surf (1E-2)	-	2E-14	2E-8	2E-7
	Y, see <sup>234</sup> Pu	-	2E-2 Bone surf (2E-2)	7E-12	-	-	-
94 Plutonium-245	W, see <sup>234</sup> Pu	2E+3	5E+3	2E-6	6E-9	3E-5	3E-4
	Y, see <sup>234</sup> Pu	-	4E+3	2E-6	6E-9	-	-
94 Plutonium-246	W, see <sup>234</sup> Pu	4E+2 LLI wall (4E+2)	3E+2	1E-7	4E-10	-	-
	Y, see <sup>234</sup> Pu	-	3E+2	1E-7	4E-10	-	-
95 Americium-237 <sup>2</sup>	W, all compounds	8E+4	3E+5	1E-4	4E-7	1E-3	1E-2
95 Americium-238 <sup>2</sup>	W, all compounds	4E+4	3E+3 Bone surf (6E+3)	1E-6	-	5E-4	5E-3
		-	-	-	9E-9	-	-
95 Americium-239	W, all compounds	5E+3	1E+4	5E-6	2E-8	7E-5	7E-4
95 Americium-240	W, all compounds	2E+3	3E+3	1E-6	4E-9	3E-5	3E-4
95 Americium-241	W, all compounds	8E-1	6E-3	3E-12	-	-	-
		Bone surf (1E+0)	Bone surf (1E-2)	-	2E-14	2E-8	2E-7
95 Americium-242m	W, all compounds	8E-1	6E-3	3E-12	-	-	-
		Bone surf (1E+0)	Bone surf (1E-2)	-	2E-14	2E-8	2E-7
95 Americium-242	W, all compounds	4E+3	8E+1 Bone surf (9E+1)	4E-8	-	5E-5	5E-4
		-	-	-	1E-10	-	-
95 Americium-243	W, all compounds	8E-1	6E-3	3E-12	-	-	-
		Bone surf (1E+0)	Bone surf (1E-2)	-	2E-14	2E-8	2E-7

Atomic Radio-nuclide No.	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
		Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	Monthly Average Concentration (μCi/ml)
		Oral Ingestion	INHALATION		Air (μCi/ml)	Water (μCi/ml)	
		ALI (μCi)	ALI (μCi)	DAC (μCi/ml)			
95 Americium-244m <sup>2</sup>	W, all compounds	6E+4	4E+3	2E-6	-	-	-
		St wall	Bone surf				
		(8E+4)	(7E+3)	-	1E-8	1E-3	1E-2
95 Americium-244	W, all compounds	3E+3	2E+2	8E-8	-	4E-5	4E-4
			Bone surf				
		-	(3E+2)	-	4E-10	-	-
95 Americium-245	W, all compounds	3E+4	8E+4	3E-5	1E-7	4E-4	4E-3
95 Americium-246m <sup>2</sup>	W, all compounds	5E+4	2E+5	8E-5	3E-7	-	-
		(6E+4)	-	-	-	8E-4	8E-3
95 Americium-246 <sup>2</sup>	W, all compounds	3E+4	1E+5	4E-5	1E-7	4E-4	4E-3
96 Curium-238	W, all compounds	2E+4	1E+3	5E-7	2E-9	2E-4	2E-3
96 Curium-240	W, all compounds	6E+1	6E-1	2E-10	-	-	-
		Bone surf	Bone surf				
		(8E+1)	(6E-1)	-	9E-13	1E-6	1E-5
96 Curium-241	W, all compounds	1E+3	3E+1	1E-8	-	2E-5	2E-4
			Bone surf				
		-	(4E+1)	-	5E-11	-	-
96 Curium-242	W, all compounds	3E+1	3E-1	1E-10	-	-	-
		Bone surf	Bone surf				
		(5E+1)	(3E-1)	-	4E-13	7E-7	7E-6
96 Curium-243	W, all compounds	1E+0	9E-3	4E-12	-	-	-
		Bone surf	Bone surf				
		(2E+0)	(2E-2)	-	2E-14	3E-8	3E-7
96 Curium-244	W, all compounds	1E+0	1E-2	5E-12	-	-	-
		Bone surf	Bone surf				
		(3E+0)	(2E-2)	-	3E-14	3E-8	3E-7
96 Curium-245	W, all compounds	7E-1	6E-3	3E-12	-	-	-
		Bone surf	Bone surf				
		(1E+0)	(1E-2)	-	2E-14	2E-8	2E-7
96 Curium-246	W, all compounds	7E-1	6E-3	3E-12	-	-	-
		Bone surf	Bone surf				
		(1E+0)	(1E-2)	-	2E-14	2E-8	2E-7
96 Curium-247	W, all compounds	8E-1	6E-3	3E-12	-	-	-
		Bone surf	Bone surf				
		(1E+0)	(1E-2)	-	2E-14	2E-8	2E-7
96 Curium-248	W, all compounds	2E-1	2E-3	7E-13	-	-	-
		Bone surf	Bone surf				
		(4E-1)	(3E-3)	-	4E-15	5E-9	5E-8

Atomic Radio-nuclide No.	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers	
		Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	Monthly Average Concentration (μCi/ml)	
		Oral Ingestion	INHALATION		Air (μCi/ml)	Water (μCi/ml)		
			ALI (μCi)	ALI (μCi)				DAC (μCi/ml)
96	Curium-249 <sup>2</sup>	W, all compounds	5E+4	2E+4 Bone surf	7E-6	-	7E-4	7E-3
			-	(3E+4)	-	4E-8	-	-
96	Curium-250	W, all compounds	4E-2 Bone surf	3E-4 Bone surf	1E-13	-	-	-
			(6E-2)	(5E-4)	-	8E-16	9E-10	9E-9
97	Berkelium-245	W, all compounds	2E+3	1E+3	5E-7	2E-9	3E-5	3E-4
97	Berkelium-246	W, all compounds	3E+3	3E+3	1E-6	4E-9	4E-5	4E-4
97	Berkelium-247	W, all compounds	5E-1 Bone surf	4E-3 Bone surf	2E-12	-	-	-
			(1E+0)	(9E-3)	-	1E-14	2E-8	2E-7
97	Berkelium-249	W, all compounds	2E+2 Bone surf	2E+0 Bone surf	7E-10	-	-	-
			(5E+2)	(4E+0)	-	5E-12	6E-6	6E-5
97	Berkelium-250	W, all compounds	9E+3	3E+2 Bone surf	1E-7	-	1E-4	1E-3
			-	(7E+2)	-	1E-9	-	-
98	Californium-244 <sup>2</sup>	W, all compounds except those given for Y	3E+4 St wall	6E+2	2E-7	8E-10	-	-
			(3E+4)	-	-	-	4E-4	4E-3
		Y, oxides and hydroxides	-	6E+2	2E-7	8E-10	-	-
98	Californium-246	W, see <sup>244</sup> Cf	4E+2	9E+0	4E-9	1E-11	5E-6	5E-5
		Y, see <sup>244</sup> Cf	-	9E+0	4E-9	1E-11	-	-
98	Californium-248	W, see <sup>244</sup> Cf	8E+0 Bone surf	6E-2 Bone surf	3E-11	-	-	-
			(2E+1)	(1E-1)	-	2E-13	2E-7	2E-6
		Y, see <sup>244</sup> Cf	-	1E-1	4E-11	1E-13	-	-
98	Californium-249	W, see <sup>244</sup> Cf	5E-1 Bone surf	4E-3 Bone surf	2E-12	-	-	-
			(1E+0)	(9E-3)	-	1E-14	2E-8	2E-7
		Y, see <sup>244</sup> Cf	-	1E-2 Bone surf	4E-12	-	-	-
			-	(1E-2)	-	2E-14	-	-
98	Californium-250	W, see <sup>244</sup> Cf	1E+0 Bone surf	9E-3 Bone surf	4E-12	-	-	-
			(2E+0)	(2E-2)	-	3E-14	3E-8	3E-7
		Y, see <sup>244</sup> Cf	-	3E-2	1E-11	4E-14	-	-

Atomic Radio-nuclide No.	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers	
		Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	Monthly Average Concentration (μCi/ml)	
		Oral Ingestion	INHALATION		Air (μCi/ml)	Water (μCi/ml)		
		ALI (μCi)	ALI (μCi)	DAC (μCi/ml)				
98	Californium-251	W, see <sup>244</sup> Cf	5E-1 Bone surf (1E+0)	4E-3 Bone surf (9E-3)	2E-12	-	-	2E-7
		Y, see <sup>244</sup> Cf	-	1E-2 Bone surf (1E-2)	4E-12	-	-	-
98	Californium-252	W, see <sup>244</sup> Cf	2E+0 Bone surf (5E+0)	2E-2 Bone surf (4E-2)	8E-12	-	-	-
		Y, see <sup>244</sup> Cf	-	3E-2	1E-11	5E-14	-	-
98	Californium-253	W, see <sup>244</sup> Cf	2E+2 Bone surf (4E+2)	2E+0	8E-10	3E-12	-	-
		Y, see <sup>244</sup> Cf	-	2E+0	7E-10	2E-12	5E-6	5E-5
98	Californium-254	W, see <sup>244</sup> Cf	2E+0	2E-2	9E-12	3E-14	3E-8	3E-7
		Y, see <sup>244</sup> Cf	-	2E-2	7E-12	2E-14	-	-
99	Einsteinium-250	W, all compounds	4E+4 Bone surf (1E+3)	5E+2	2E-7	-	6E-4	6E-3
99	Einsteinium-251	W, all compounds	7E+3	9E+2 Bone surf (1E+3)	4E-7	-	1E-4	1E-3
99	Einsteinium-253	W, all compounds	2E+2	1E+0	6E-10	2E-12	2E-6	2E-5
99	Einsteinium-254m	W, all compounds	3E+2	1E+1	4E-9	1E-11	-	-
99	Einsteinium-254	W, all compounds	(3E+2) Bone surf (2E+1)	-	-	-	4E-6	4E-5
			8E+0 Bone surf (2E+1)	7E-2 Bone surf (1E-1)	3E-11	-	-	-
100	Fermium-252	W, all compounds	5E+2	1E+1	5E-9	2E-11	6E-6	6E-5
100	Fermium-253	W, all compounds	1E+3	1E+1	4E-9	1E-11	1E-5	1E-4
100	Fermium-254	W, all compounds	3E+3	9E+1	4E-8	1E-10	4E-5	4E-4
100	Fermium-255	W, all compounds	5E+2	2E+1	9E-9	3E-11	7E-6	7E-5
100	Fermium-257	W, all compounds	2E+1 Bone surf (4E+1)	2E-1 Bone surf (2E-1)	7E-11	-	-	-
101	Mendelevium-257	W, all compounds	7E+3	8E+1 Bone surf	4E-8	-	1E-4	1E-3

Atomic Radio-nuclide No.	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
		Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	Monthly Average Concentration (μCi/ml)
		Oral Ingestion ALI (μCi)	INHALATION ALI (μCi) DAC (μCi/ml)		Air (μCi/ml)	Water (μCi/ml)	
101	Mendelevium-258	W, all compounds	(9E+1)	-	1E-10	-	-
			3E+1	2E-1	1E-10	-	-
			Bone surf (5E+1)	Bone surf (3E-1)	-	5E-13	6E-7
							6E-6
		- Any single radionuclide not listed above with decay mode other than alpha emission or spontaneous fission and with radioactive half-life less than 2 hours Submersion <sup>1</sup>	-	2E+2	1E-7	1E-9	-
		- Any single radionuclide not listed above with decay mode other than alpha emission or spontaneous fission and with radioactive half-life greater than 2 hours	-	2E-1	1E-10	1E-12	1E-8
		- Any single radionuclide not listed above that decays by alpha emission or spontaneous fission, or any mixture for which either the identity or the concentration of any radio-nuclide in the mixture is not known	-	4E-4	2E-13	1E-15	2E-9
							2E-8

FOOTNOTES:

<sup>1</sup>“Submersion” means that values given are for submersion in a hemispherical semi-infinite cloud of airborne material.

<sup>2</sup>These radionuclides have radiological half-lives of less than 2 hours. The total effective dose equivalent received during operations with these radionuclides might include a significant contribution from external exposure. The DAC values for all radionuclides, other than those designated Class “Submersion,” are based upon the committed effective dose equivalent due to the intake of the radionuclide into the body and do NOT include potentially significant contributions to dose equivalent from external exposures. The licensee may substitute 1E-7 μCi/ml for the listed DAC to account for the submersion dose prospectively, but should use individual monitoring devices or other radiation measuring instruments that measure external exposure to demonstrate compliance with the limits. (see 40.17)

<sup>3</sup>For soluble mixtures of U-238, U-234, and U-235 in air, chemical toxicity may be the limiting factor (see 40.15(5)). If the percent by weight (enrichment) of U-235 is not greater than 5, the concentration value for a 40-hour workweek is 0.2 milligrams uranium per cubic meter of air average. For any enrichment, the product of the average concentration and time of exposure during a 40-hour workweek shall not exceed 8E-3 (SA) μCi-hr/ml, where SA is the specific activity of the uranium inhaled. The specific activity for natural uranium is 6.77E-7 curies per gram U. The specific activity for other mixtures of U-238, U-235, and U-234, if not known, shall be:

$$SA = 3.6E-7 \text{ curies/gram U U-depleted}$$

$$SA = [0.4 + 0.38 (\text{enrichment}) + 0.0034 (\text{enrichment})^2] E-6, \text{ enrichment} \geq 0.72$$

where enrichment is the percentage by weight of U-235, expressed as percent.

NOTE:

1. If the identity of each radionuclide in a mixture is known but the concentration of one or more of the radionuclides in the mixture is not known, the DAC for the mixture shall be the most restrictive DAC of any radionuclide in the mixture.

2. If the identity of each radionuclide in the mixture is not known, but it is known that certain radionuclides specified in this appendix are not present in the mixture, the inhalation ALI, DAC, and effluent and sewage concentrations for the mixture are the lowest values specified in this appendix for any radionuclide that is not known to be absent from the mixture; or

If it is known that Ac-227-D and Cm-250-W are not present

-	7E-4	3E-13	-	-	-
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If, in addition, it is known that Ac-227-W,Y, Th-229-W,Y, Th-230-W, Th-232-W,Y, Pa-231-W,Y, Np-237-W, Pu-239-W, Pu-240-W, Pu-242-W, Am-241-W, Am-242m-W, Am-243-W, Cm-245-W, Cm-246-W, Cm-247-W, Cm-248-W, Bk-247-W, Cf-249-W, and Cf-251-W are not present

-	7E-3	3E-12	-	-	-
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If, in addition, it is known that Sm-146-W, Sm-147-W, Gd-148-D,W, Gd-152-D,W, Th-228-W,Y, Th-230-Y, U-232-Y, U-233-Y, U-234-Y, U-235-Y, U-236-Y, U-238-Y, Np-236-W, Pu-236-W,Y, Pu-238-W,Y, Pu-239-Y, Pu-240-Y, Pu-242-Y, Pu-244-W,Y, Cm-243-W, Cm-244-W, Cf-248-W, Cf-249-Y, Cf-250-W,Y, Cf-251-Y, Cf-252-W,Y, and Cf-254-W,Y are not present

-	7E-2	3E-11	-	-	-
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Atomic Radio-nuclide No.	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
		Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	Monthly Average Concentration (μCi/ml)
		Oral Ingestion ALI (μCi)	INHALATION ALI (μCi) DAC (μCi/ml)		Air (μCi/ml)	Water (μCi/ml)	
If, in addition, it is known that Pb-210-D, Bi-210m-W, Po-210-D,W, Ra-223-W, Ra-225-W, Ra-226-W, Ac-225-D,W,Y, Th-227-W,Y, U-230-D,W,Y, U-232-D,W, Pu-241-W, Cm-240-W, Cm-242-W, Cf-248-Y, Es-254-W, Fm-257-W, and Md-258-W are not present							
		-	7E-1	3E-10	-	-	-
If, in addition, it is known that Si-32-Y, Ti-44-Y, Fe-60-D, Sr-90-Y, Zr-93-D,Cd-113m-D, Cd-113-D, In-115-D,W, La-138-D, Lu-176-W, Hf-178m-D,W, Hf-182-D,W, Bi-210m-D, Ra-224-W, Ra-228-W, Ac-226-D,W,Y, Pa-230-W,Y, U-233-D,W, U-234-D,W, U-235-D, W, U-236-D,W, U-238-D,W, Pu-241-Y, Bk-249-W, Cf-253-W,Y, and Es-253-W are not present							
		-	7E+0	3E-9	-	-	-
If it is known that Ac-227-D,W,Y, Th-229-W,Y, Th-232-W,Y, Pa-231-W, Y, Cm-248-W, and Cm-250-W are not present							
		-	-	-	-	1E-14	-
If, in addition, it is known that Sm-146-W, Gd-148-D,W, Gd-152-D, Th-228-W,Y, Th-230-W,Y, U-232-Y, U-233-Y, U-234-Y, U-235-Y, U-236-Y, U-238-Y, U-Nat-Y, Np-236-W, Np-237-W, Pu-236-W,Y, Pu-238-W,Y, Pu-239-W,Y, Pu-240-W,Y, Pu-242-W,Y, Pu-244-W,Y, Am-241-W, Am-242m-W, Am-243-W, Cm-243-W, Cm-244-W, Cm-245-W, Cm-246-W, Cm-247-W, Bk-247-W, Cf-249-W,Y, Cf-250-W,Y, Cf-251-W,Y, Cf-252-W,Y, and Cf-254-W,Y are not present							
		-	-	-	1E-13	-	-
If, in addition, it is known that Sm-147-W, Gd-152-W, Pb-210-D, Bi-210m-W, Po-210-D,W, Ra-223-W, Ra-225-W, Ra-226-W, Ac-225-D, W,Y, Th-227-W,Y, U-230-D,W,Y, U-232-D,W, U-Nat-W, Pu-241-W, Cm-240-W, Cm-242-W, Cf-248-W,Y, Es-254-W, Fm-257-W, and Md-258-W are not present							
		-	-	-	-	1E-12	-
If, in addition it is known that Fe-60, Sr-90, Cd-113m, Cd-113, In-115, I-129, Cs-134, Sm-145, Sm-147, Gd-148, Gd-152, Hg-194 (organic), Bi-210m, Ra-223, Ra-224, Ra-225, Ac-225, Th-228, Th-230, U-233, U-234, U-235, U-236, U-238, U-Nat, Cm-242, Cf-248, Es-254, Fm-257, and Md-258 are not present							
		-	-	-	-	1E-6	1E-5

3. If a mixture of radionuclides consists of uranium and its daughters in ore dust (10 μm AMAD particle distribution assumed) prior to chemical separation of the uranium from the ore, the following values may be used for the DAC of the mixture: 6E-11 μCi of gross alpha activity from uranium-238, uranium-234, thorium-230, and radium-226 per milliliter of air; 3E-11 μCi of natural uranium per milliliter of air; or 45 micrograms of natural uranium per cubic meter of air.

4. If the identity and concentration of each radionuclide in a mixture are known, the limiting values should be derived as follows: determine, for each radionuclide in the mixture, the ratio between the concentration present in the mixture and the concentration otherwise established in Appendix B, Chapter 40 for the specific radionuclide when not in a mixture. The sum of such ratios for all of the radionuclides in the mixture may not exceed "1" (i.e., "unity").

EXAMPLE: If radionuclides "A," "B," and "C" are present in concentrations C<sub>A</sub>, C<sub>B</sub>, and C<sub>C</sub>, and if the applicable DACs are DAC<sub>A</sub>, DAC<sub>B</sub>, and DAC<sub>C</sub>, respectively, then the concentrations shall be limited so that the following relationship exists:

$$\frac{C_A}{DAC_A} + \frac{C_B}{DAC_B} + \frac{C_C}{DAC_C} \leq 1$$

## CHAPTER 40

## APPENDIX C

QUANTITIES<sup>1</sup> OF LICENSED OR REGISTERED MATERIAL REQUIRING LABELING

Radionuclide	Quantity ( $\mu$ Ci)*	Radionuclide	Quantity ( $\mu$ Ci)*
Hydrogen-3	1,000	Chromium-48	1,000
Beryllium-7	1,000	Chromium-49	1,000
Beryllium-10	1	Chromium-51	1,000
Carbon-11	1,000	Manganese-51	1,000
Carbon-14	100	Manganese-52m	1,000
Fluorine-18	1,000	Manganese-52	100
Sodium-22	10	Manganese-53	1,000
Sodium-24	100	Manganese-54	100
Magnesium-28	100	Manganese-56	1,000
Aluminum-26	10	Iron-52	100
Silicon-31	1,000	Iron-55	100
Silicon-32	1	Iron-59	10
Phosphorus-32	10	Iron-60	1
Phosphorus-33	100	Cobalt-55	100
Sulfur-35	100	Cobalt-56	10
Chlorine-36	10	Cobalt-57	100
Chlorine-38	1,000	Cobalt-58m	1,000
Chlorine-39	1,000	Cobalt-58	100
Argon-39	1,000	Cobalt-60m	1,000
Argon-41	1,000	Cobalt-60	1
Potassium-40	100	Cobalt-61	1,000
Potassium-42	1,000	Cobalt-62m	1,000
Potassium-43	1,000	Nickel-56	100
Potassium-44	1,000	Nickel-57	100
Potassium-45	1,000	Nickel-59	100
Calcium-41	100	Nickel-63	100
Calcium-45	100	Nickel-65	1,000
Calcium-47	100	Nickel-66	10
Scandium-43	1,000	Copper-60	1,000
Scandium-44m	100	Copper-61	1,000
Scandium-44	100	Copper-64	1,000
Scandium-46	10	Copper-67	1,000
Scandium-47	100	Zinc-62	100
Scandium-48	100	Zinc-63	1,000
Scandium-49	1,000	Zinc-65	10
Titanium-44	1	Zinc-69m	100

Titanium-45	1,000	Zinc-69	1,000
Vanadium-47	1,000	Zinc-71m	1,000
Vanadium-48	100	Zinc-72	100
Vanadium-49	1,000	Gallium-65	1,000
Gallium-66	100	Krypton-81	1,000
Gallium-67	1,000	Krypton-83m	1,000
Gallium-68	1,000	Krypton-85m	1,000
Gallium-70	1,000	Krypton-85	1,000
Gallium-72	100	Krypton-87	1,000
Gallium-73	1,000	Krypton-88	1,000
Germanium-66	1,000	Rubidium-79	1,000
Germanium-67	1,000	Rubidium-81m	1,000
Germanium-68	10	Rubidium-81	1,000
Germanium-69	1,000	Rubidium-82m	1,000
Germanium-71	1,000	Rubidium-83	100
Germanium-75	1,000	Rubidium-84	100
Germanium-77	1,000	Rubidium-86	100
Germanium-78	1,000	Rubidium-87	100
Arsenic-69	1,000	Rubidium-88	1,000
Arsenic-70	1,000	Rubidium-89	1,000
Arsenic-71	100	Strontium-80	100
Arsenic-72	100	Strontium-81	1,000
Arsenic-73	100	Strontium-83	100
Arsenic-74	100	Strontium-85m	1,000
Arsenic-76	100	Strontium-85	100
Arsenic-77	100	Strontium-87m	1,000
Arsenic-78	1,000	Strontium-89	10
Selenium-70	1,000	Strontium-90	0.1
Selenium-73m	1,000	Strontium-91	100
Selenium-73	100	Strontium-92	100
Selenium-75	100	Yttrium-86m	1,000
Selenium-79	100	Yttrium-86	100
Selenium-81m	1,000	Yttrium-87	100
Selenium-81	1,000	Yttrium-88	10
Selenium-83	1,000	Yttrium-90m	1,000
Bromine-74m	1,000	Yttrium-90	10
Bromine-74	1,000	Yttrium-91m	1,000
Bromine-75	1,000	Yttrium-91	10
Bromine-76	100	Yttrium-92	100
Bromine-77	1,000	Yttrium-93	100
Bromine-80m	1,000	Yttrium-94	1,000



Bromine-80	1,000	Yttrium-95	1,000
Bromine-82	100	Zirconium-86	100
Bromine-83	1,000	Zirconium-88	10
Bromine-84	1,000	Zirconium-89	100
Krypton-74	1,000	Zirconium-93	1
Krypton-76	1,000	Zirconium-95	10
Krypton-77	1,000	Zirconium-97	100
Krypton-79	1,000		
Niobium-88	1,000	Palladium-101	1,000
Niobium-89m (66 min)	1,000	Palladium-103	100
Niobium-89 (122 min)	1,000	Palladium-107	10
Niobium-90	100	Palladium-109	100
Niobium-93m	10	Silver-102	1,000
Niobium-94	1	Silver-103	1,000
Niobium-95m	100	Silver-104m	1,000
Niobium-95	100	Silver-104	1,000
Niobium-96	100	Silver-105	100
Niobium-97	1,000	Silver-106m	100
Niobium-98	1,000	Silver-106	1,000
Molybdenum-90	100	Silver-108m	1
Molybdenum-93m	100	Silver-110m	10
Molybdenum-93	10	Silver-111	100
Molybdenum-99	100	Silver-112	100
Molybdenum-101	1,000	Silver-115	1,000
Technetium-93m	1,000	Cadmium-104	1,000
Technetium-93	1,000	Cadmium-107	1,000
Technetium-94m	1,000	Cadmium-109	1
Technetium-94	1,000	Cadmium-113m	0.1
Technetium-96m	1,000	Cadmium-113	100
Technetium-96	100	Cadmium-115m	10
Technetium-97m	100	Cadmium-115	100
Technetium-97	1,000	Cadmium-117m	1,000
Technetium-98	10	Cadmium-117	1,000
Technetium-99m	1,000	Indium-109	1,000
Technetium-99	100	Indium-110m (69.1m)	1,000
Technetium-101	1,000	Indium-110 (4.9h)	1,000
Technetium-104	1,000	Indium-111	100
Ruthenium-94	1,000	Indium-112	1,000
Ruthenium-97	1,000	Indium-113m	1,000

Ruthenium-103	100	Indium-114m	10
Ruthenium-105	1,000	Indium-115m	1,000
Ruthenium-106	1	Indium-115	100
Rhodium-99m	1,000	Indium-116m	1,000
Rhodium-99	100	Indium-117m	1,000
Rhodium-100	100	Indium-117	1,000
Rhodium-101m	1,000	Indium-119m	1,000
Rhodium-101	10	Tin-110	100
Rhodium-102m	10	Tin-111	1,000
Rhodium-102	10	Tin-113	100
Rhodium-103m	1,000	Tin-117m	100
Rhodium-105	100	Tin-119m	100
Rhodium-106m	1,000	Tin-121m	100
Rhodium-107	1,000	Tin-121	1,000
Palladium-100	100		
Tin-123m	1,000	Tellurium-133	1,000
Tin-123	10	Tellurium-134	1,000
Tin-125	10	Iodine-120m	1,000
Tin-126	10	Iodine-120	100
Tin-127	1,000	Iodine-121	1,000
Tin-128	1,000	Iodine-123	100
Antimony-115	1,000	Iodine-124	10
Antimony-116m	1,000	Iodine-125	1
Antimony-116	1,000	Iodine-126	1
Antimony-117	1,000	Iodine-128	1,000
Antimony-118m	1,000	Iodine-129	1
Antimony-119	1,000	Iodine-130	10
Antimony-120		Iodine-131	1
(16m)	1,000	Iodine-132m	100
Antimony-120		Iodine-132	100
(5.76d)	100	Iodine-133	10
Antimony-122	100	Iodine-134	1,000
Antimony-124m	1,000	Iodine-135	100
Antimony-124	10	Xenon-120	1,000
Antimony-125	100	Xenon-121	1,000
Antimony-126m	1,000	Xenon-122	1,000
Antimony-126	100	Xenon-123	1,000
Antimony-127	100	Xenon-125	1,000
Antimony-128		Xenon-127	1,000
(10.4m)	1,000	Xenon-129m	1,000
Antimony-128		Xenon-131m	1,000

(9.01h)	100	Xenon-133m	1,000
Antimony-129	100	Xenon-133	1,000
Antimony-130	1,000	Xenon-135m	1,000
Antimony-131	1,000	Xenon-135	1,000
Tellurium-116	1,000	Xenon-138	1,000
Tellurium-121m	10	Cesium-125	1,000
Tellurium-121	100	Cesium-127	1,000
Tellurium-123m	10	Cesium-129	1,000
Tellurium-123	100	Cesium-130	1,000
Tellurium-125m	10	Cesium-131	1,000
Tellurium-127m	10	Cesium-132	100
Tellurium-127	1,000	Cesium-134m	1,000
Tellurium-129m	10	Cesium-134	10
Tellurium-129	1,000	Cesium-135m	1,000
Tellurium-131m	10	Cesium-135	100
Tellurium-131	100	Cesium-136	10
Tellurium-132	10	Cesium-137	10
Tellurium-133m	100	Cesium-138	1,000
Barium-126	1,000	Promethium-141	1,000
Barium-128	100	Promethium-143	100
Barium-131m	1,000	Promethium-144	10
Barium-131	100	Promethium-145	10
Barium-133m	100	Promethium-146	1
Barium-133	100	Promethium-147	10
Barium-135m	100	Promethium-148m	10
Barium-139	1,000	Promethium-148	10
Barium-140	100	Promethium-149	100
Barium-141	1,000	Promethium-150	1,000
Barium-142	1,000	Promethium-151	100
Lanthanum-131	1,000	Samarium-141m	1,000
Lanthanum-132	100	Samarium-141	1,000
Lanthanum-135	1,000	Samarium-142	1,000
Lanthanum-137	10	Samarium-145	100
Lanthanum-138	100	Samarium-146	1
Lanthanum-140	100	Samarium-147	100
Lanthanum-141	100	Samarium-151	10
Lanthanum-142	1,000	Samarium-153	100
Lanthanum-143	1,000	Samarium-155	1,000
Cerium-134	100	Samarium-156	1,000
Cerium-135	100	Europium-145	100
Cerium-137m	100	Europium-146	100
Cerium-137	1,000	Europium-147	100

Cerium-139	100	Europium-148	10
Cerium-141	100	Europium-149	100
Cerium-143	100	Europium-150	
Cerium-144	1	(12.62h)	100
Praseodymium-136	1,000	Europium-150	
Praseodymium-137	1,000	(34.2y)	1
Praseodymium-138m	1,000	Europium-152m	100
Praseodymium-139	1,000	Europium-152	1
Praseodymium-142m	1,000	Europium-154	1
Praseodymium-142	100	Europium-155	10
Praseodymium-143	100	Europium-156	100
Praseodymium-144	1,000	Europium-157	100
Praseodymium-145	100	Europium-158	1,000
Praseodymium-147	1,000	Gadolinium-145	1,000
Neodymium-136	1,000	Gadolinium-146	10
Neodymium-138	100	Gadolinium-147	100
Neodymium-139m	1,000	Gadolinium-148	0.001
Neodymium-139	1,000	Gadolinium-149	100
Neodymium-141	1,000	Gadolinium-151	10
Neodymium-147	100	Gadolinium-152	100
Neodymium-149	1,000	Gadolinium-153	10
Neodymium-151	1,000	Gadolinium-159	100
Terbium-147	1,000	Ytterbium-162	1,000
Terbium-149	100	Ytterbium-166	100
Terbium-150	1,000	Ytterbium-167	1,000
Terbium-151	100	Ytterbium-169	100
Terbium-153	1,000	Ytterbium-175	100
Terbium-154	100	Ytterbium-177	1,000
Terbium-155	1,000	Ytterbium-178	1,000
Terbium-156m		Lutetium-169	100
(5.0h)	1,000	Lutetium-170	100
Terbium-156m		Lutetium-171	100
(24.4h)	1,000	Lutetium-172	100
Terbium-156	100	Lutetium-173	10
Terbium-157	10	Lutetium-174m	10
Terbium-158	1	Lutetium-174	10
Terbium-160	10	Lutetium-176m	1,000
Terbium-161	100	Lutetium-176	100
Dysprosium-155	1,000	Lutetium-177m	10
Dysprosium-157	1,000	Lutetium-177	100
Dysprosium-159	100	Lutetium-178m	1,000
Dysprosium-165	1,000	Lutetium-178	1,000

Dysprosium-166	100	Lutetium-179	1,000
Holmium-155	1,000	Hafnium-170	100
Holmium-157	1,000	Hafnium-172	1
Holmium-159	1,000	Hafnium-173	1,000
Holmium-161	1,000	Hafnium-175	100
Holmium-162m	1,000	Hafnium-177m	1,000
Holmium-162	1,000	Hafnium-178m	0.1
Holmium-164m	1,000	Hafnium-179m	10
Holmium-164	1,000	Hafnium-180m	1,000
Holmium-166m	1	Hafnium-181	10
Holmium-166	100	Hafnium-182m	1,000
Holmium-167	1,000	Hafnium-182	0.1
Erbium-161	1,000	Hafnium-183	1,000
Erbium-165	1,000	Hafnium-184	100
Erbium-169	100	Tantalum-172	1,000
Erbium-171	100	Tantalum-173	1,000
Erbium-172	100	Tantalum-174	1,000
Thulium-162	1,000	Tantalum-175	1,000
Thulium-166	100	Tantalum-176	100
Thulium-167	100	Tantalum-177	1,000
Thulium-170	10	Tantalum-178	1,000
Thulium-171	10	Tantalum-179	100
Thulium-172	100	Tantalum-180m	1,000
Thulium-173	100	Tantalum-180	100
Thulium-175	1,000	Tantalum-182m	1,000
Tantalum-182	10	Iridium-188	100
Tantalum-183	100	Iridium-189	100
Tantalum-184	100	Iridium-190m	1,000
Tantalum-185	1,000	Iridium-190	100
Tantalum-186	1,000	Iridium-192m	
Tungsten-176	1,000	(1.4m)	10
Tungsten-177	1,000	Iridium-192	
Tungsten-178	1,000	(73.8d)	1
Tungsten-179	1,000	Iridium-194m	10
Tungsten-181	1,000	Iridium-194	100
Tungsten-185	100	Iridium-195m	1,000
Tungsten-187	100	Iridium-195	1,000
Tungsten-188	10	Platinum-186	1,000
Rhenium-177	1,000	Platinum-188	100
Rhenium-178	1,000	Platinum-189	1,000
Rhenium-181	1,000	Platinum-191	100
Rhenium-182		Platinum-193m	100

(12.7h)	1,000	Platinum-193	1,000
Rhenium-182		Platinum-195m	100
(64.0h)	100	Platinum-197m	1,000
Rhenium-184m	10	Platinum-197	100
Rhenium-184	100	Platinum-199	1,000
Rhenium-186m	10	Platinum-200	100
Rhenium-186	100	Gold-193	1,000
Rhenium-187	1,000	Gold-194	100
Rhenium-188m	1,000	Gold-195	10
Rhenium-188	100	Gold-198m	100
Rhenium-189	100	Gold-198	100
Osmium-180	1,000	Gold-199	100
Osmium-181	1,000	Gold-200m	100
Osmium-182	100	Gold-200	1,000
Osmium-185	100	Gold-201	1,000
Osmium-189m	1,000	Mercury-193m	100
Osmium-191m	1,000	Mercury-193	1,000
Osmium-191	100	Mercury-194	1
Osmium-193	100	Mercury-195m	100
Osmium-194	1	Mercury-195	1,000
Iridium-182	1,000	Mercury-197m	100
Iridium-184	1,000	Mercury-197	1,000
Iridium-185	1,000	Mercury-199m	1,000
Iridium-186	100	Mercury-203	100
Iridium-187	1,000		
Thallium-194m	1,000	Francium-223	100
Thallium-194	1,000	Radium-223	0.1
Thallium-195	1,000	Radium-224	0.1
Thallium-197	1,000	Radium-225	0.1
Thallium-198m	1,000	Radium-226	0.1
Thallium-198	1,000	Radium-227	1,000
Thallium-199	1,000	Radium-228	0.1
Thallium-200	1,000	Actinium-224	1
Thallium-201	1,000	Actinium-225	0.01
Thallium-202	100	Actinium-226	0.1
Thallium-204	100	Actinium-227	0.001
Lead-195m	1,000	Actinium-228	1
Lead-198	1,000	Thorium-226	10
Lead-199	1,000	Thorium-227	0.01
Lead-200	100	Thorium-228	0.001
Lead-201	1,000	Thorium-229	0.001
Lead-202m	1,000	Thorium-230	0.001

Lead-202	10	Thorium-231	100
Lead-203	1,000	Thorium-232	100
Lead-205	100	Thorium-234	10
Lead-209	1,000	Thorium-natural	100
Lead-210	0.01	Protactinium-227	10
Lead-211	100	Protactinium-228	1
Lead-212	1	Protactinium-230	0.1
Lead-214	100	Protactinium-231	0.001
Bismuth-200	1,000	Protactinium-232	1
Bismuth-201	1,000	Protactinium-233	100
Bismuth-202	1,000	Protactinium-234	100
Bismuth-203	100	Uranium-230	0.01
Bismuth-205	100	Uranium-231	100
Bismuth-206	100	Uranium-232	0.001
Bismuth-207	10	Uranium-233	0.001
Bismuth-210m	0.1	Uranium-234	0.001
Bismuth-210	1	Uranium-235	0.001
Bismuth-212	10	Uranium-236	0.001
Bismuth-213	10	Uranium-237	100
Bismuth-214	100	Uranium-238	100
Polonium-203	1,000	Uranium-239	1,000
Polonium-205	1,000	Uranium-240	100
Polonium-207	1,000	Uranium-natural	100
Polonium-210	0.1	Neptunium-232	100
Astatine-207	100	Neptunium-233	1,000
Astatine-211	10	Neptunium-234	100
Radon-220	1	Neptunium-235	100
Radon-222	1	Neptunium-236	
Francium-222	100	(1.15E+5)	0.001
Neptunium-236 (22.5h)	1	Curium-242	0.01
Neptunium-237	0.001	Curium-243	0.001
Neptunium-238	10	Curium-244	0.001
Neptunium-239	100	Curium-245	0.001
Neptunium-240	1,000	Curium-246	0.001
Plutonium-234	10	Curium-247	0.001
Plutonium-235	1,000	Curium-248	0.001
Plutonium-236	0.001	Curium-249	1,000
Plutonium-237	100	Berkelium-245	100
Plutonium-238	0.001	Berkelium-246	100
Plutonium-239	0.001	Berkelium-247	0.001
		Berkelium-249	0.1

Plutonium-240	0.001	Berkelium-250	10
Plutonium-241	0.01	Californium-244	100
Plutonium-242	0.001	Californium-246	1
Plutonium-243	1,000	Californium-248	0.01
Plutonium-244	0.001	Californium-249	0.001
Plutonium-245	100	Californium-250	0.001
Americium-237	1,000	Californium-251	0.001
Americium-238	100	Californium-252	0.001
Americium-239	1,000	Californium-253	0.1
Americium-240	100	Californium-254	0.001
Americium-241	0.001	Einsteinium-250	100
Americium-242m	0.001	Einsteinium-251	100
Americium-242	10	Einsteinium-253	0.1
Americium-243	0.001	Einsteinium-254m	1
Americium-244m	100	Einsteinium-254	0.01
Americium-244	10	Fermium-252	1
Americium-245	1,000	Fermium-253	1
Americium-246m	1,000	Fermium-254	10
Americium-246	1,000	Fermium-255	1
Curium-238	100	Fermium-257	0.01
Curium-240	0.1	Mendelevium-257	10
Curium-241	1	Mendelevium-258	0.01
Any alpha-emitting radionuclide not listed above or mixtures of alpha emitters of unknown composition	0.001	Any radionuclide other than alpha-emitting radionuclides not listed above, or mixtures of beta emitters of unknown composition	0.01

\*To convert  $\mu\text{Ci}$  to  $\text{kBq}$ , multiply the  $\mu\text{Ci}$  value by 37.

<sup>1</sup>The quantities listed above were derived by taking 1/10th of the most restrictive ALI listed in Table I, Columns 1 and 2, of Appendix B to this chapter, rounding to the nearest factor of 10, and constraining the values listed between 37 Bq and 37 MBq (0.001 and 1,000  $\mu\text{Ci}$ ). Values of 3.7 MBq (100  $\mu\text{Ci}$ ) have been assigned for radionuclides having a radioactive half-life in excess of E+9 years, except rhenium, 37 MBq (1,000  $\mu\text{Ci}$ ), to take into account their low specific activity.

NOTE: For purposes of 40.61(5), 40.64(1), and 40.95(1) where there is involved a combination of radionuclides in known amounts, the limit for the combination shall be derived as follows: determine, for each radionuclide in the combination, the ratio between the quantity present in the combination and the limit otherwise established for the specific radionuclide when not in combination. The sum of such ratios for all radionuclides in the combination may not exceed "1"—that is, unity.



## CHAPTER 40

## APPENDIX D

## REQUIREMENTS FOR TRANSFERS AND MANIFESTS OF LOW-LEVEL RADIOACTIVE WASTE INTENDED FOR DISPOSAL AT LICENSED LAND DISPOSAL FACILITIES

As used in this appendix, the following definitions apply:

“Chelating agent” means amine polycarboxylic acids (e.g., EDTA, DTPA), hydroxy-carboxylic acids, and polycarboxylic acids (e.g., citric acid, carboic acid, and glucinic acid).

“Chemical description” means a description of the principal chemical characteristics of a low-level radioactive waste.

“Computer-readable medium” means that the regulatory agency’s computer can transfer the information from the medium into its memory.

“Consignee” means the designated receiver of the shipment of low-level radioactive waste.

“Decontamination facility” means a facility operating under an Agreement State or Nuclear Regulatory Commission license whose principal purpose is decontamination of equipment or materials to accomplish recycle, reuse, or other waste management objectives and, for purposes of this appendix, is not considered to be a consignee for LLW shipments.

“Disposal container” means a container principally used to confine low-level radioactive waste during disposal operations at a land disposal facility (also see “high integrity container”). Note that for some shipments, the disposal container may be the transport package.

“EPA identification number” means the number received by a transporter following application to the administrator of EPA as required by 40 CFR Part 263.

“Forms 540, 540A, 541, 541A, 542, and 542A” are official forms referenced in this appendix. Licensees need not use originals of these forms as long as any substitute forms are equivalent to the original documentation in respect to content, clarity, size, and location of information. Upon agreement between the shipper and consignee, Forms 541 (and 541A) and Forms 542 (and 542A) may be completed, transmitted, and stored in electronic media. The electronic media must have the capability for producing legible, accurate, and complete records in the format of the uniform manifest.

“Generator” means a licensee operating under an Agreement State or Nuclear Regulatory Commission license who (1) is a waste generator as defined in this rule, or (2) is the licensee to whom waste can be attributed within the context of the Low-Level Radioactive Waste Policy Amendments Act of 1985 (e.g., waste generated as a result of decontamination or recycle activities).

“High integrity container (HIC)” means a container commonly designed to meet the structural stability requirements of 10 CFR 61.56, and to meet United States Department of Transportation requirements for a Type A package.

“Land disposal facility” means the land, buildings and structures, and equipment which are intended to be used for the disposal of radioactive wastes. For purposes of this appendix, a “geologic repository” as defined in 10 CFR Part 60 is not considered a land disposal facility.

“Package” means the assembly of components necessary to ensure compliance with the packaging requirements of United States Department of Transportation regulations, together with its radioactive contents, as presented for transport.

“Physical description” means the items called for on Form 541 to describe a low-level radioactive waste.

“Residual waste” means low-level radioactive waste resulting from processing or decontamination activities that cannot be easily separated into distinct batches attributable to specific waste generators. This waste is attributable to the processor or decontamination facility, as applicable.

“Shipper” means the licensed entity (i.e., the waste generator, waste collector, or waste processor) who offers low-level radioactive waste for transportation, typically consigning this type of waste to a licensed waste collector, waste processor, or land disposal facility operator.

“Shipping paper” means Form 540 and, if required, Form 540A which includes the information required by United States Department of Transportation in 49 CFR Part 172.

“Uniform Low-Level Radioactive Waste Manifest” or “uniform manifest” means the combination of Forms 540, 541 and, if necessary, 542, and their respective continuation sheets as needed, or equivalent.

“Waste collector” means an entity, operating under an Agreement State or Nuclear Regulatory Commission license, whose principal purpose is to collect and consolidate waste generated by others, and to transfer this waste, without processing or repackaging the collected waste, to another licensed waste collector, licensed waste processor, or licensed land disposal facility.

“Waste description” means the physical, chemical and radiological description of a low-level radioactive waste as called for on Form 541.

“Waste generator” means an entity, operating under an Agreement State or Nuclear Regulatory Commission license, who (1) possesses any material or component that contains radioactivity or is radioactively contaminated for which the licensee foresees no further use, and (2) transfers this material or component to a licensed land disposal facility or to a licensed waste collector or processor for handling or treatment prior to disposal. A licensee performing processing or decontamination services may be a “waste generator” if the transfer of low-level radioactive waste from its facility is defined as “residual waste.”

“Waste processor” means an entity, operating under an Agreement State or Nuclear Regulatory Commission license, whose principal purpose is to process, repackage, or otherwise treat low-level radioactive material or waste generated by others prior to eventual transfer of waste to a licensed low-level radioactive waste land disposal facility.

“Waste type” means a waste within a disposal container having a unique physical description (i.e., a specific waste descriptor code or description; or a waste sorbed on or solidified in a specifically defined media).

#### I. Manifest

A waste generator, collector, or processor who transports, or offers for transportation, low-level radioactive waste intended for ultimate disposal at a licensed low-level radioactive waste land disposal facility must prepare a manifest reflecting information requested on applicable Forms 540 (Uniform Low-Level Radioactive Waste Manifest (Shipping Paper)) and 541 (Uniform Low-Level Radioactive Waste Manifest (Container and Waste Description)) and, if necessary, on an applicable Form 542 (Uniform Low-Level Radioactive Waste Manifest (Manifest Index and Regional Compact Tabulation)). Forms 540 and 540A must be completed and must physically accompany the pertinent low-level waste shipment. Upon agreement between shipper and consignee, Forms 541 and 541A and 542 and 542A may be completed, transmitted, and stored in electronic media with the capability for producing legible, accurate, and complete records on the respective forms. Licensees are not required by this agency to comply with the manifesting requirements of this part when they ship:

(a) LLW for processing and expect its return (i.e., for storage under their license) prior to disposal at a licensed land disposal facility;

(b) LLW that is being returned to the licensee who is the “waste generator” or “generator,” as defined in this part; or

(c) Radioactively contaminated material to a “waste processor” that becomes the processor’s “residual waste.”

For guidance in completing these forms, refer to the instructions that accompany the forms. Copies of manifests required by this appendix may be legible carbon copies, photocopies, or computer printouts that reproduce the data in the format of the uniform manifest.

NRC Forms 540, 540A, 541, 541A, 542, and 542A, and the accompanying instructions, in hard copy, may be obtained by writing or calling the Office of Information Services, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0111, telephone (301) 415-5877 or by visiting the NRC’s Web site at <http://www.nrc.gov> and selecting forms from the index found on the home page.

This appendix includes information requirements of the United States Department of Transportation, as codified in 49 CFR Part 172. Information on hazardous, medical, or other waste required to meet Environmental Protection Agency regulations, as codified in 40 CFR Parts 259, 261, or elsewhere, is not addressed in this section, and must be provided on the required EPA forms. However, the required EPA forms must accompany the Uniform Low-Level Radioactive Waste Manifest required by this chapter.

### Information Requirements

#### A. General Information

The shipper of the radioactive waste shall provide the following information on the uniform manifest:

1. The name, facility's address, and telephone number of the licensee shipping the waste;
2. An explicit declaration indicating whether the shipper is acting as a waste generator, collector, processor, or a combination of these identifiers for purposes of the manifested shipment; and
3. The name, address, and telephone number, or the name and EPA identification number, for the carrier transporting the waste.

#### B. Shipment Information

The shipper of the radioactive waste shall provide the following information regarding the waste shipment on the uniform manifest:

1. The date of the waste shipment;
2. The total number of packages/disposal containers;
3. The total disposal volume and disposal weight in the shipment;
4. The total radionuclide activity in the shipment;
5. The activity of each of the radionuclides, H-3, C-14, Tc-99, and I-129 contained in the shipment; and
6. The total masses of U-233, U-235, and plutonium in special nuclear material, and the total mass of uranium and thorium in source material.

#### C. Disposal Container and Waste Information

The shipper of the radioactive waste shall provide the following information on the uniform manifest regarding the waste and each disposal container of waste in the shipment:

1. An alphabetic or numeric identification that uniquely identifies each disposal container in the shipment;
2. A physical description of the disposal container, including the manufacturer and model of any high integrity container;
3. The volume displaced by the disposal container;
4. The gross weight of the disposal container, including the waste;
5. For waste consigned to a disposal facility, the maximum radiation level at the surface of each disposal container;
6. A physical and chemical description of the waste;
7. The total weight percentage of chelating agent for any waste containing more than 0.1 percent chelating agent by weight, plus the identity of the principal chelating agent;
8. The approximate volume of waste within a container;
9. The sorbing or solidification media, if any, and the identity of the solidification media vendor and brand name;
10. The identities and activities of individual radionuclides contained in each container, the masses of U-233, U-235, and plutonium in special nuclear material, and the masses of uranium and thorium in source material. For discrete waste types (i.e., activated materials, contaminated equipment, mechanical filters, sealed source/devices, and wastes in solidification/stabilization media), the identities and activities of individual radionuclides associated with or contained in these waste types within a disposal container shall be reported;
11. The total radioactivity within each container; and
12. For wastes consigned to a disposal facility, the classification of the waste pursuant to 10 CFR 61.55. Waste not meeting the structural stability requirements of 10 CFR 61.56(b) must be identified.

#### D. Uncontainerized Waste Information

The shipper of the radioactive waste shall provide the following information on the uniform manifest regarding a waste shipment delivered without a disposal container:

1. The approximate volume and weight of the waste;
2. A physical and chemical description of the waste;
3. The total weight percentage of chelating agent if the chelating agent exceeds 0.1 percent by weight, plus the identity of the principal chelating agent;

4. For waste consigned to a disposal facility, the classification of the waste pursuant to 10 CFR 61.55. Waste not meeting the structural stability requirements of 10 CFR 61.56(b) must be identified;

5. The identities and activities of individual radionuclides contained in the waste, the masses of U-233, U-235, and plutonium in special nuclear material, and the masses of uranium and thorium in source material; and

6. For wastes consigned to a disposal facility, the maximum radiation levels at the surface of the waste.

#### E. Multigenerator Disposal Container Information

This section applies to disposal containers enclosing mixtures of waste originating from different generators. (Note: The origin of the LLW resulting from a processor's activities may be attributable to one or more "generators" (including "waste generators") as defined in this appendix.) It also applies to mixtures of wastes shipped in an uncontainerized form, for which portions of the mixture within the shipment originate from different generators.

1. For homogeneous mixtures of waste, such as incinerator ash, provide the waste description applicable to the mixture and the volume of the waste attributed to each generator.

2. For heterogeneous mixtures of waste, such as the combined products from a large compactor, identify each generator contributing waste to the disposal container and, for discrete waste types (i.e., activated materials, contaminated equipment, mechanical filters, sealed source/devices, and wastes in solidification/stabilization media), the identities and activities of individual radionuclides contained in these waste types within the disposal container. For each generator, provide the following:

(a) The volume of waste within the disposal container;

(b) A physical and chemical description of the waste, including the solidification agent, if any;

(c) The total weight percentage of chelating agents for any disposal container containing more than 0.1 percent chelating agent by weight, plus the identity of the principal chelating agent;

(d) The sorbing or solidification media, if any, and the identity of the solidification media vendor and brand name if the media is claimed to meet stability requirements in 10 CFR 61.56(b); and

(e) Radionuclide identities and activities contained in the waste, the masses of U-233, U-235, and plutonium in special nuclear material, and the masses of uranium and thorium in source material if contained in the waste.

#### II. Certification

An authorized representative of the waste generator, processor, or collector shall certify by signing and dating the shipment manifest that the transported materials are properly classified, described, packaged, marked, and labeled and are in proper condition for transportation according to the applicable regulations of the United States Department of Transportation and this agency. A collector in signing the certification is certifying that nothing has been done to the collected waste that would invalidate the waste generator's certification.

#### III. Control and Tracking

A. Any licensee who transfers radioactive waste to a land disposal facility or a licensed waste collector shall comply with the requirements in paragraphs A.1. through A.9. of this appendix. Any licensee who transfers waste to a licensed waste processor for waste treatment or repackaging shall comply with the requirements of paragraphs A.4. through A.9. of this appendix. A licensee shall:

1. Prepare all wastes so that the waste is classified according to 10 CFR 61.55 and meets the waste characteristics requirements in 10 CFR 61.56;

2. Label each disposal container (or transport package if potential radiation hazards preclude labeling of the individual disposal container) of waste to identify whether it is Class A waste, Class B waste, Class C waste, or greater than Class C waste, in accordance with 10 CFR 61.55;

3. Conduct a quality assurance program to ensure compliance with 10 CFR 61.55 and 61.56 (the program must include management evaluation of audits);

4. Prepare the Uniform Low-Level Radioactive Waste Manifest as required by this appendix;

5. Forward a copy or electronically transfer the Uniform Low-Level Radioactive Waste Manifest to the intended consignee so that either (1) receipt of the manifest precedes the LLW shipment or (2) the

manifest is delivered to the consignee with the waste at the time the waste is transferred to the consignee. Using both (1) and (2) is also acceptable;

6. Include Form 540 (and Form 540A, if required) with the shipment regardless of the option chosen in paragraph A.5. of this section;

7. Receive acknowledgment of the receipt of the shipment in the form of a signed copy of Form 540;

8. Retain a copy of or electronically store the Uniform Low-Level Radioactive Waste Manifest and documentation of acknowledgment of receipt as the record of transfer of licensed material as required by 641—subrule 39.4(41); and

9. For any shipments or any part of a shipment for which acknowledgment of receipt has not been received within the times set forth in this appendix, conduct an investigation in accordance with paragraph E of this appendix.

B. Any waste collector licensee who handles only prepackaged waste shall:

1. Acknowledge receipt of the waste from the shipper within one week of receipt by returning a signed copy of Form 540;

2. Prepare a new manifest to reflect consolidated shipments that meet the requirements of this appendix. The waste collector shall ensure that, for each container of waste in the shipment, the manifest identifies the generator of that container of waste;

3. Forward a copy or electronically transfer the Uniform Low-Level Radioactive Waste Manifest to the intended consignee so that either: (1) receipt of the manifest precedes the LLW shipment or (2) the manifest is delivered to the consignee with the waste at the time the waste is transferred to the consignee. Using both (1) and (2) is also acceptable;

4. Include Form 540 (and Form 540A, if required) with the shipment regardless of the option chosen in paragraph B.3. of this section;

5. Receive acknowledgment of the receipt of the shipment in the form of a signed copy of Form 540;

6. Retain a copy of or electronically store the Uniform Low-Level Radioactive Waste Manifest and documentation of acknowledgment of receipt as the record of transfer of licensed material as required by 641—subrule 39.4(41);

7. For any shipments or any part of a shipment for which acknowledgment of receipt has not been received within the times set forth in this appendix, conduct an investigation in accordance with paragraph E of this appendix; and

8. Notify the shipper and this agency when any shipment, or part of a shipment, has not arrived within 60 days after receipt of an advance manifest, unless notified by the shipper that the shipment has been canceled.

C. Any licensed waste processor who treats or repackages waste shall:

1. Acknowledge receipt of the waste from the shipper within one week of receipt by returning a signed copy of Form 540;

2. Prepare a new manifest that meets the requirements of this appendix. Preparation of the new manifest reflects that the processor is responsible for meeting these requirements. For each container of waste in the shipment, the manifest shall identify the waste generators, the preprocessed waste volume, and the other information as required in paragraph E.1. of this appendix;

3. Prepare all wastes so that the waste is classified according to 10 CFR 61.55 and meets the waste characteristics requirements in 10 CFR 61.56;

4. Label each package of waste to identify whether it is Class A waste, Class B waste, or Class C waste, in accordance with 10 CFR 61.55 and 61.57;

5. Conduct a quality assurance program to ensure compliance with 10 CFR 61.55 and 61.56 (the program shall include management evaluation of audits);

6. Forward a copy or electronically transfer the Uniform Low-Level Radioactive Waste Manifest to the intended consignee so that either (1) receipt of the manifest precedes the LLW shipment or (2) the manifest is delivered to the consignee with the waste at the time the waste is transferred to the consignee. Using both (1) and (2) is also acceptable;

7. Include Form 540 (and Form 540A, if required) with the shipment regardless of the option chosen in paragraph C.6. of this section;
8. Receive acknowledgment of the receipt of the shipment in the form of a signed copy of Form 540;
9. Retain a copy of or electronically store the Uniform Low-Level Radioactive Waste Manifest and documentation of acknowledgment of receipt as the record of transfer of licensed material as required by 641—subrule 39.4(41);
10. For any shipment or any part of a shipment for which acknowledgment of receipt has not been received within the times set forth in this appendix, conduct an investigation in accordance with paragraph E of this appendix; and
11. Notify the shipper and this agency of any shipment, or part of a shipment, that has not arrived within 60 days after receipt of an advance manifest, unless notified by the shipper that the shipment has been canceled.
  - D. The land disposal facility operator shall:
    1. Acknowledge receipt of the waste within one week of receipt by returning, as a minimum, a signed copy of Form 540 to the shipper. The shipper to be notified is the licensee who last possessed the waste and transferred the waste to the operator. If any discrepancy exists between materials listed on the Uniform Low-Level Radioactive Waste Manifest and materials received, copies or electronic transfer of the affected forms must be returned indicating the discrepancy;
    2. Maintain copies of all completed manifests and electronically store the information required by 10 CFR 61.80(l) until the license is terminated; and
    3. Notify the shipper and this agency when any shipment, or part of a shipment, has not arrived within 60 days after receipt of an advance manifest, unless notified by the shipper that the shipment has been canceled.
  - E. Any shipment or part of a shipment for which acknowledgment is not received within the times set forth in this section must:
    1. Be investigated by the shipper if the shipper has not received notification or receipt within 20 days after transfer; and
    2. Be traced and reported. The investigation shall include tracing the shipment and filing a report with this agency. Each licensee who conducts a trace investigation shall file a written report with this agency within two weeks of completion of the investigation.

## CHAPTER 40

## APPENDIX E

CLASSIFICATION AND CHARACTERISTICS OF LOW-LEVEL  
RADIOACTIVE WASTE

## I. Classification of Radioactive Waste for Land Disposal

a) Considerations. Determination of the classification of radioactive waste involves two considerations. First, consideration must be given to the concentration of long-lived radionuclides (and their shorter-lived precursors) whose potential hazard will persist long after such precautions as institutional controls, improved waste form, and deeper disposal have ceased to be effective. These precautions delay the time when long-lived radionuclides could cause exposures. In addition, the magnitude of the potential dose is limited by the concentration and availability of the radionuclide at the time of exposure. Second, consideration must be given to the concentration of shorter-lived radionuclides for which requirements on institutional controls, waste form, and disposal methods are effective.

## b) Classes of waste.

1) Class A waste is waste that is usually segregated from other waste classes at the disposal site. The physical form and characteristics of Class A waste must meet the minimum requirements set forth in Section II. (a). If Class A waste also meets the stability requirements set forth in Section II. (b), it is not necessary to segregate the waste for disposal.

2) Class B waste is waste that must meet more rigorous requirements on waste form to ensure stability after disposal. The physical form and characteristics of Class B waste must meet both the minimum and stability requirements set forth in Section II.

3) Class C waste is waste that not only must meet more rigorous requirements on waste form to ensure stability but also requires additional measures at the disposal facility to protect against inadvertent intrusion. The physical form and characteristics of Class C waste must meet both the minimum and stability requirements set forth in Section II.

c) Classification determined by long-lived radionuclides. If the radioactive waste contains only radionuclides listed in Table I, classification shall be determined as follows:

1) If the concentration does not exceed 0.1 times the value in Table I, the waste is Class A.

2) If the concentration exceeds 0.1 times the value in Table I, but does not exceed the value in Table I, the waste is Class C.

3) If the concentration exceeds the value in Table I, the waste is not generally acceptable for land disposal.

4) For wastes containing mixtures of radionuclides listed in Table I, the total concentration shall be determined by the sum of fractions rule described in Section I.(g).

TABLE I

Radionuclide	Concentration	
	curie/cubic meter <sup>a</sup>	nanocurie/gram <sup>b</sup>
C-14	8	
C-14 in activated metal	80	
Ni-59 in activated metal	220	
Nb-94 in activated metal	0.2	
Tc-99	3	
I-129	0.08	

Alpha emitting transuranic radionuclides with half-life greater than five years	100
Pu-241	3,500
Cm-242	20,000
Ra-226	100

<sup>a</sup> To convert the Ci/m<sup>3</sup> values to gigabecquerel (GBq) per cubic meter, multiply the Ci/m<sup>3</sup> value by 37.

<sup>b</sup> To convert the nCi/g values to becquerel (Bq) per gram, multiply the nCi/g value by 37.

d) Classification determined by short-lived radionuclides. If the waste does not contain any of the radionuclides listed in Table I, classification shall be determined based on the concentrations shown in Table II. However, as specified in Section I.(f), if radioactive waste does not contain any nuclides listed in either Table I or II, it is Class A.

- 1) If the concentration does not exceed the value in Column 1, the waste is Class A.
- 2) If the concentration exceeds the value in Column 1 but does not exceed the value in Column 2, the waste is Class B.
- 3) If the concentration exceeds the value in Column 2 but does not exceed the value in Column 3, the waste is Class C.
- 4) If the concentration exceeds the value in Column 3, the waste is not generally acceptable for near-surface disposal.
- 5) For wastes containing mixtures of the radionuclides listed in Table II, the total concentration shall be determined by the sum of fractions rule described in Section I.(g).

TABLE II

Radionuclide	Concentration, curie/cubic meter *		
	Column 1	Column 2	Column 3
Total of all radionuclides with less than 5-year half-life	700	*	*
H-3	40	*	*
Co-60	700	*	*
Ni-63	3.5	70	700
Ni-63 in activated metal	35	700	7000
Sr-90	0.04	150	7000
Cs-137	1	44	4600

\*AGENCY NOTE: To convert the Ci/m<sup>3</sup> value to gigabecquerel (GBq) per cubic meter, multiply the Ci/m<sup>3</sup> value by 37. There are no limits established for these radionuclides in Class B or C wastes. Practical considerations such as the effects of external radiation and internal heat generation on transportation, handling, and disposal will limit the concentrations for these wastes. These wastes shall be Class B unless the concentrations of other radionuclides in Table II determine the waste to be Class C independent of these radionuclides.

e) Classification determined by both long- and short-lived radionuclides. If the radioactive waste contains a mixture of radionuclides, some of which are listed in Table I and some of which are listed in Table II, classification shall be determined as follows:

- 1) If the concentration of a radionuclide listed in Table I is less than 0.1 times the value listed in Table I, the class shall be that determined by the concentration of radionuclides listed in Table II.
- 2) If the concentration of a radionuclide listed in Table I exceeds 0.1 times the value listed in Table I, but does not exceed the value in Table I, the waste shall be Class C, provided the concentration of radionuclides listed in Table II does not exceed the value shown in Column 3 of Table II.



f) Classification of wastes with radionuclides other than those listed in Tables I and II. If the waste does not contain any radionuclides listed in either Table I or II, it is Class A.

g) Determination of concentrations in wastes. The concentration of a radionuclide may be determined by indirect methods such as use of scaling factors which relate the inferred concentration of one radionuclide to another that is measured, or radionuclide material accountability, if there is reasonable assurance that the indirect methods can be correlated with actual measurements. The concentration of a radionuclide may be averaged over the volume of the waste, or weight of the waste if the units are expressed as becquerel (nanocurie) per gram.

h) The sum of the fractions rule for mixtures of radionuclides. For determining classification for waste that contains a mixture of radionuclides, it is necessary to determine the sum of fractions by dividing each radionuclide's concentration by the appropriate limit and adding the resulting values. The appropriate limits must all be taken from the same column of the same table. The sum of the fractions for the column must be less than 1.0 if the waste class is to be determined by that column. Example: A waste contains Sr-90 in a concentration of 1.85 TBq/m<sup>3</sup> (50 Ci/m<sup>3</sup>) and Cs-137 in a concentration of 814 GBq/m<sup>3</sup> (22 Ci/m<sup>3</sup>). Since the concentrations both exceed the values in Column 1, Table II, they must be compared to Column 2 values. For Sr-90 fraction,  $50/150 = 0.33$ ; for Cs-137 fraction,  $22/44 = 0.5$ ; the sum of the fractions = 0.83. Since the sum is less than 1.0, the waste is Class B.

## II. Radioactive Waste Characteristics

a) The following are minimum requirements for all classes of waste and are intended to facilitate handling and provide protection of health and safety of personnel at the disposal site.

1) Wastes shall be packaged in conformance with the conditions of the license issued to the site operator to which the waste will be shipped. Where the conditions of the site license are more restrictive than the provisions of this chapter, the site license conditions shall govern.

2) Wastes shall not be packaged for disposal in cardboard or fiberboard boxes.

3) Liquid waste shall be packaged in sufficient absorbent material to absorb twice the volume of the liquid.

4) Solid waste containing liquid shall contain as little freestanding and noncorrosive liquid as is reasonably achievable, but in no case shall the liquid exceed 1% of the volume.

5) Waste shall not be readily capable of detonation or of explosive decomposition or reaction at normal pressures and temperatures, or of explosive reaction with water.

6) Waste shall not contain, or be capable of generating, quantities of toxic gases, vapors, or fumes harmful to persons transporting, handling, or disposing of the waste. This does not apply to radioactive gaseous waste packaged in accordance with Section II.(a)(8).

7) Waste must not be pyrophoric. Pyrophoric materials contained in wastes shall be treated, prepared, and packaged to be nonflammable.<sup>4</sup>

8) Wastes in a gaseous form shall be packaged at an absolute pressure that does not exceed 1.5 atmospheres at 20°C. Total activity shall not exceed 100 Ci (3.7 TBq) per container.

<sup>4</sup>See 641—38.2 of these rules for the definition of pyrophoric.

9) Wastes containing hazardous, biological, pathogenic, or infectious material shall be treated to reduce to the maximum extent practicable the potential hazard from the nonradiological materials.

b) The following requirements are intended to provide stability of the waste. Stability is intended to ensure that the waste does not degrade and affect overall stability of the site through slumping, collapse, or other failure of the disposal unit and thereby lead to water infiltration. Stability is also a factor in limiting exposure to an inadvertent intruder, since it provides a recognizable and nondispersible waste.

1) Waste shall have structural stability. A structurally stable waste form will generally maintain its physical dimensions and its form, under the expected disposal conditions such as weight of overburden and compaction equipment, the presence of moisture, and microbial activity, and internal factors such as radiation effects and chemical changes. Structural stability can be provided by the waste form itself, processing the waste to a stable form, or placing the waste in a disposal container or structure that provides stability after disposal.

2) Notwithstanding the provisions in Section II.(a)(3) and (4), liquid wastes, or wastes containing liquid, shall be converted into a form that contains as little freestanding and noncorrosive liquid as is reasonably achievable, but in no case shall the liquid exceed 1% of the volume of the waste when the waste is in a disposal container designed to ensure stability, or 0.5% of the volume of the waste for waste processed to a stable form.

3) Void spaces within the waste and between the waste and its package shall be reduced to the extent practicable.

### III. Labeling

Each package of waste shall be clearly labeled to identify whether it is Class A, Class B, or Class C waste, in accordance with Section I.

## CHAPTER 40

## APPENDIX F

## QUANTITIES FOR USE WITH DECOMMISSIONING

<u>Material</u>	<u>Microcurie*</u>
Americium-241	0.01
Antimony-122	100
Antimony-124	10
Antimony-125	10
Arsenic-73	100
Arsenic-74	10
Arsenic-76	10
Arsenic-77	100
Barium-131	10
Barium-133	10
Barium-140	10
Bismuth-210	1
Bromine-82	10
Cadmium-109	10
Cadmium-115m	10
Cadmium-115	100
Calcium-45	10
Calcium-47	10
Carbon-14	100
Cerium-141	100
Cerium-143	100
Cerium-144	1
Cesium-131	1,000
Cesium-134m	100
Cesium-134	1
Cesium-135	10
Cesium-136	10
Cesium-137	10
Chlorine-36	10
Chlorine-38	10
Chromium-51	1,000
Cobalt-58m	10
Cobalt-58	10
Cobalt-60	1
Copper-64	100
Dysprosium-165	10
Dysprosium-166	100

<u>Material</u>	<u>Microcurie*</u>
Erbium-169	100
Erbium-171	100
Europium-152 (9.2 h)	100
Europium-152 (13 yr)	1
Europium-154	1
Europium-155	10
Florine-18	1,000
Gadolinium-153	10
Gadolinium-159	100
Gallium-72	10
Germanium-71	100
Gold-198	100
Gold-199	100
Hafnium-181	10
Holmium-166	100
Hydrogen-3	1,000
Indium-113m	100
Indium-114m	10
Indium-115m	100
Indium-115	10
Iodine-125	1
Iodine-126	1
Iodine-129	0.1
Iodine-131	1
Iodine-132	10
Iodine-133	1
Iodine-134	10
Iodine-135	10
Iridium-192	10
Iridium-194	100
Iron-55	100
Iron-59	10
Krypton-85	100
Krypton-87	10
Lanthanum-140	10
Lutetium-177	100
Manganese-52	10
Manganese-54	10
Manganese-56	10
Mercury-197m	100
Mercury-197	100

<u>Material</u>	<u>Microcurie*</u>
Mercury-203	10
Molybdenum-99	100
Neodymium-147	100
Neodymium-149	100
Nickel-59	100
Nickel-63	10
Nickel-65	100
Niobium-93m	10
Niobium-95	10
Niobium-97	10
Osmium-185	10
Osmium-191m	100
Osmium-191	100
Osmium-193	100
Palladium-103	100
Palladium-109	100
Phosphorus-32	10
Platinum-191	100
Platinum-193m	100
Platinum-193	100
Platinum-197m	100
Platinum-197	100
Plutonium-239	0.01
Polonium-210	0.1
Potassium-42	10
Praseodymium-142	100
Praseodymium-143	100
Promethium-147	10
Promethium-149	10
Radium-226	0.01
Rhenium-186	100
Rhenium-188	100
Rhodium-103m	100
Rhodium-105	100
Rubidium-86	10
Rubidium-87	10
Ruthenium-97	100
Ruthenium-103	10
Ruthenium-105	10
Ruthenium-106	1
Samarium-151	10

<u>Material</u>	<u>Microcurie*</u>
Samarium-153	100
Scandium-46	10
Scandium-47	100
Scandium-48	10
Selenium-75	10
Silicon-31	100
Silver-105	10
Silver-110m	1
Silver-111	100
Sodium-22	1
Sodium-24	10
Strontium-85	10
Strontium-89	1
Strontium-90	0.1
Strontium-91	10
Strontium-92	10
Sulfur-35	100
Tantalum-182	10
Technetium-96	10
Technetium-97m	100
Technetium-97	100
Technetium-99m	100
Technetium-99	10
Tellurium-125m	10
Tellurium-127m	10
Tellurium-127	100
Tellurium-129m	10
Tellurium-129	100
Tellurium-131m	10
Tellurium-132	10
Terbium-160	10
Thallium-200	100
Thallium-201	100
Thallium-202	100
Thallium-204	10
Thorium (natural)**	100
Thulium-170	10
Thulium-171	10
Tin-113	10
Tin-125	10
Tungsten-181	10

<u>Material</u>	<u>Microcurie*</u>
Tungsten-185	10
Tungsten-187	100
Uranium (natural)**	100
Uranium-233	0.01
Uranium-234	0.01
Uranium-235	0.01
Vanadium-48	10
Xenon-131m	1,000
Xenon-133	100
Xenon-135	100
Ytterbium-175	100
Yttrium-90	10
Yttrium-91	10
Yttrium-92	100
Yttrium-93	100
Zinc-65	10
Zinc-69m	100
Zinc-69	1,000
Zirconium-93	10
Zirconium-95	10
Zirconium-97	10
Any alpha-emitting radionuclide not listed above or mixtures of alpha emitters of unknown composition	0.01
Any radionuclide other than alpha-emitting radionuclides, not listed above or mixtures of beta emitters of unknown composition	0.1

\*To convert  $\mu\text{Ci}$  to kBq, multiply the  $\mu\text{Ci}$  value by 37.

\*\*Based on alpha disintegration rate of U-238, U-234, and U-235.

NOTE: This Appendix is retained for use by those Agreement States that need to adopt decommissioning regulations compatible with the U.S. Nuclear Regulatory Commission.

NOTE: Where there is involved a combination of isotopes in known amounts, the limit for the combination should be derived as follows: Determine, for each isotope in the combination, the ratio between the quantity present in the combination and the limit otherwise established for the specific isotope when not in combination. The sum of such ratios for all the isotopes in the combination may not exceed "1"—that is, unity.

## CHAPTER 40

## APPENDIX G

## RADIONUCLIDES OF CONCERN

Radionuclide	Quantity of Concern <sup>1</sup> (TBq)	Quantity of Concern <sup>2</sup> (Ci)
Am-241	0.6	16
Am-241/Be	0.6	16
Cf-252	0.2	5.4
Cm-244	0.5	14
Co-60	0.3	8.1
Cs-137	1	27
Gd-153	10	270
Ir-192	0.8	22
Pm-147	400	11,000
Pu-238	0.6	16
Pu-239/Be	0.6	16
Ra-226	0.4	11
Se-75	2	54
Sr-90 (Y-90)	10	270
Tm-170	200	5,400
Yb-169	3	81
Combinations of radioactive materials listed above <sup>3</sup>	See footnote below <sup>4</sup>	

<sup>1</sup>The aggregate activity of multiple, collocated sources of the same radionuclide should be included when the total activity equals or exceeds the quantity of concern.

<sup>2</sup>The primary values used for compliance with this Order are TBq. The curie (Ci) values are rounded to two significant figures for informational purposes only.

<sup>3</sup>Radioactive materials are to be considered aggregated or collocated if breaching a common physical security barrier (e.g., a locked door at the entrance to a storage room) would allow access to the radioactive material or devices containing the radioactive material.

<sup>4</sup>If several radionuclides are aggregated, the sum of the ratios of the activity of each source,  $i$  of radionuclide,  $n$ ,  $A_{(i,n)}$ , to the quantity of concern for radionuclide  $n$ ,  $Q_{(n)}$ , listed for that radionuclide equals or exceeds one. [(aggregated source activity for radionuclide A) ÷ (quantity of concern for radionuclide A)] + [(aggregated source activity for radionuclide B) ÷ (quantity of concern for radionuclide B)] + etc. .... ≥ 1

Use the following method to determine which sources of radioactive material require increased controls (ICs):

- Include any single source equal to or greater than the quantity of concern in Appendix G.
- Include multiple collocated sources of the same radionuclide when the combined quantity equals or exceeds the quantity of concern.
- For combinations of radionuclides, include multiple collocated sources of different radionuclides when the aggregate quantities satisfy the following unity rule: [(amount of radionuclide A) ÷ (quantity of concern of radionuclide A)] + [(amount of radionuclide B) ÷ (quantity of concern of radionuclide B)] + etc. .... ≥ 1

## Guidance for Aggregation of Sources

NRC supports the use of the IAEA's source categorization methodology as defined in TECDOC-1344, "Categorization of Radioactive Sources," (July 2003) (see [http://www-pub.iaea.org/MTCD/publications/PDF/te\\_1344\\_web.pdf](http://www-pub.iaea.org/MTCD/publications/PDF/te_1344_web.pdf)) and as endorsed by the agency's Code of Conduct for the Safety and Security of Radioactive Sources, January 2004 (see <http://www-pub.iaea.org/MTCD/publications/PDF/Code-2004.pdf>). The Code defines a three-tiered



source categorization scheme. Category 1 corresponds to the largest source strength (equal to or greater than 100 times the quantity of concern values listed in the table in Appendix G) and Category 3 corresponds to the smallest (equal to or exceeding one-tenth the quantity of concern values listed in the table in Appendix G). Increased controls apply to sources that are equal to or greater than the quantity of concern values listed in the table in Appendix G, plus aggregations of smaller sources that are equal to or greater than the quantities in the table in Appendix G. Aggregation only applies to sources that are collocated.

Licensees that possess sources in total quantities that equal or exceed the table in Appendix G quantities are required to implement increased controls. Where there are many small (less than the quantity of concern values) collocated sources whose total aggregate activity equals or exceeds the table in Appendix G values, licensees are to implement increased controls.

Some source handling or storage activities may cover several buildings or several locations within specific buildings. The question then becomes: When are sources considered collocated for purposes of aggregation? For purposes of the additional controls, sources are considered collocated if breaching a single barrier (e.g., a locked door at the entrance to a storage room) would allow access to the sources. Sources behind an outer barrier should be aggregated separately from those behind an inner barrier (e.g., a locked source safe inside the locked storage room). However, if both barriers are simultaneously open, then all sources within these two barriers are considered to be collocated. This logic should be continued for other barriers within or behind the inner barrier.

The following example illustrates the point: A lockable room has sources stored in it. Inside the lockable room, there are two shielded safes with additional sources in them. Inventories are as follows:

The room has the following sources outside the safes: Cf-252, 0.12 TBq (3.2 Ci); Co-60, 0.18 TBq (4.9 Ci); and Pu-238, 0.3 TBq (8.1 Ci). Application of the unity rule yields:  $(0.12 \div 0.2) + (0.18 \div 0.3) + (0.3 \div 0.6) = 0.6 + 0.6 + 0.5 = 1.5$ . Therefore, the sources would require increased controls.

Shielded safe #1 has a 1.9 TBq (51 Ci) Cs-137 source and a 0.8 TBq (22 Ci) Am-241 source. In this case, the sources would require increased controls, regardless of location, because they each exceed the quantities in the table in Appendix G.

Shielded safe #2 has two Ir-192 sources, each having an activity of 0.3 TBq (8.1 Ci). In this case, the sources would not require increased controls while locked in the safe. The combined activity does not exceed the threshold quantity 0.8 TBq (22 Ci).

Because certain barriers may cease to exist during source handling operations (e.g., a storage location may be unlocked during periods of active source usage), licensees should, to the extent practicable, consider two modes of source usage—"operations" (active source usage) and "shutdown" (source storage mode). Whichever mode results in the greatest inventory (considering barrier status) would require increased controls for each location.

## CHAPTER 40

## APPENDIX H

## NATIONALLY TRACKED SOURCE THRESHOLDS

The Terabecquerel (TBq) values are the regulatory standard. The curie (Ci) values specified are obtained by converting from the TBq value. The curie values are provided for practical usefulness only and are rounded after conversion.

Radioactive Material	Category 1 (TBq)	Category 1 (Ci)	Category 2 (TBq)	Category 2 (Ci)
Actinium-227	20	540	0.2	5.4
Americium-241	60	1,600	0.6	16.0
Americium-241/Be	60	1,600	0.6	16.0
Californium-252	20	540	0.2	5.4
Cobalt-60	30	810	0.3	8.1
Curium-244	50	1,400	0.5	14.0
Cesium-137	100	2,700	1.0	27.0
Gadolinium-153	1,000	27,000	10.0	270.0
Iridium-192	80	2,200	0.8	22.0
Plutonium-238	60	1,600	0.6	16.0
Plutonium-239/Be	60	1,600	0.6	16.0
Polonium-210	60	1,600	0.6	16.0
Promethium-147	40,000	1,100,000	400.0	11,000.0
Radium-226	40	1,100	0.4	11.0
Selenium-75	200	5,400	2.0	54.0
Strontium-90	1,000	27,000	10.0	270.0
Thorium-228	20	540	0.2	5.4
Thorium-229	20	540	0.2	5.4
Thulium-170	20,000	540,000	200.0	5,400.0
Ytterbium-169	300	8,100	3.0	81.0

These rules are intended to implement Iowa Code chapter 136C.

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