**PART D**

**STANDARDS FOR PROTECTION AGAINST RADIATION**

**SUBPART A - GENERAL PROVISIONS**

**1001. Purpose.**

A. Part D establishes standards for protection against ionizing radiation resulting from activities conducted pursuant to licenses or registrations issued by the Agency. This rule is issued pursuant to 22 M.R.S., Ch. 160, the Radiation Protection Act.

B. The requirements of Part D 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 Part D. However, nothing in Part D shall be construed as limiting actions that may be necessary to protect health and safety.

**1002. Scope.** Except as specifically provided in other Parts of this rule, Part D applies to persons licensed or registered by the Agency to receive, possess, use, transfer, or dispose of sources of radiation. The limits in Part D do not apply to doses due to background radiation, to exposure of patients to radiation for the purpose of medical diagnosis or therapy, to exposure from individuals administered radioactive material and released in accordance with Part G, or to voluntary participation in medical research programs.

**1003. Definitions. (See Part A)**

**1004. Units of radiation dose (See Part A)**

**1005. Units of radioactivity (See Part A)**

**1008. Implementation.**

A. (Reserved)

B. (Reserved)

C. Any existing license or registration condition that is more restrictive than Part D remains in force until there is an amendment or renewal of the license or registration.

D. If a license or registration condition exempts a licensee or registrant from a provision of Part D in effect on or before January 1, 1994, it also exempts the licensee or registrant from the corresponding provision of Part D.

E. If a license or registration condition cites provisions of Part D in effect prior to January 1, 1994, which do not correspond to any provisions of Part D, 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.

**SUBPART B - RADIATION PROTECTION PROGRAMS**

**1101. Radiation protection programs.**

A. Each licensee or registrant shall develop, document, and implement a radiation protection program sufficient to ensure compliance with the provisions of Part D. See D.2102 for record keeping requirements relating to these programs.

B. 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).

C. The licensee or registrant shall periodically (at least annually), review the radiation protection program content and implementation.

D. To implement the ALARA requirements of D.1101.B and notwithstanding the requirements in D.1301, a constraint on air emissions of radioactive material to the environment, excluding Radon-222 and its daughters, shall be established by licensees other than those subject to 10 CFR Part 50.34a of the USNRC regulations, 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 0.1mSv (10 mrem) 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 D.2203 and promptly take appropriate corrective action to ensure against recurrence.

**SUBPART C - OCCUPATIONAL DOSE LIMITS**

**1201. Occupational dose limits for adults.**

A. The licensee or registrant shall control the occupational dose to individual adults, except for planned special exposures pursuant to D.1206, to the following dose limits:

(1) An annual limit, which is the more limiting of:

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

(b) 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 0.5 Sv (50 rem).

(2) 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:

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

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

B. 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 D.1206.E.(1) and (2).

C. When the external exposure is determined by measurement with an external personal monitoring device, the assigned deep-dose equivalent must be used in place of the effective dose equivalent, unless the effective dose equivalent is determined by a dosimetry method approved by the NRC. The assigned deep-dose equivalent must be for the part 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.

D. 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 D.2106.

E. 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.

F. 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 D.2104.E.

**1202. Compliance with requirements for summation of external and internal doses.**

A. If the licensee or registrant is required to monitor pursuant to both D.1502.A and B, 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 D.1502.A or only pursuant to D.1502.B, 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 by meeting one of the conditions specified in paragraph B of this Section and the conditions in paragraphs C and D of this Section. Note: 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.

B. Intake by inhalation. If the only intake of radionuclides is by inhalation, the total effective dose equivalent (TEDE) 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:

(1) The sum of the fractions of the inhalation ALI for each radionuclide, or

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

(3) 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, WT, and the committed dose equivalent, HT,50, per unit intake is greater than 10 percent of the maximum weighted value of HT,50 that is, WTHT,50, unit intake for any organ or tissue.

C. 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 or registrant shall account for this intake and include it in demonstrating compliance with the limits.

D. Intake through wounds or absorption through skin. The licensee or registrant shall evaluate and, to the extent practical, account for intakes through wounds or skin absorption. Note the intake through intact skin has been included in the calculation of DAC for hydrogen-3 and does not need to be further evaluated.

**1203. Determination of external dose from airborne radioactive material.**

A. Licensees or registrants 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.

B. 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.

**1204. Determination of internal exposure.**

A. For purposes of assessing dose used to determine compliance with occupational dose equivalent limits, the licensee or registrant shall, when required pursuant to D.1502, take suitable and timely measurements of:

(1) Concentrations of radioactive materials in air in work areas; or

(2) Quantities of radionuclides in the body; or

(3) Quantities of radionuclides excreted from the body; or

(4) Combinations of these measurements.

B. Unless respiratory protective equipment is used, as provided in D.1703, or the assessment of intake is based on bioassays, the licensee or registrant shall assume that an individual inhales radioactive material at the airborne concentration in which the individual is present.

C. 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 or registrant may:

(1) Use that information to calculate the committed effective dose equivalent, and, if used, the licensee or registrant shall document that information in the individual's record; and

(2) 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

(3) Separately assess the contribution of fractional intakes of Class D, W, or Y compounds of a given radionuclide to the committed effective dose equivalent (CEDE). See Appendix B.

D. If the licensee or registrant chooses to assess intakes of Class Y material using the measurements given in D.1204.A(2) or (3), the licensee or registrant may delay the recording and reporting of the assessments for periods up to seven months, unless otherwise required by D.2202 or D.2203. This delay permits the licensee or registrant to make additional measurements basic to the assessments.

E. 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:

(1) 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

(2) The ratio of the total concentration for all radionuclides in the mixture to the most restrictive DAC value for any radionuclide in the mixture.

F. 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.

G. When a mixture of radionuclides in air exists, a licensee or registrant may disregard certain radionuclides in the mixture if:

(1) The licensee or registrant uses the total activity of the mixture in demonstrating compliance with the dose limits in D.6 and in complying with the monitoring requirements in D.1502.B, and

(2) The concentration of any radionuclide disregarded is fewer than 10 percent of its DAC, and

(3) The sum of these percentages for all of the radionuclides disregarded in the mixture does not exceed 30 percent.

H. (1) 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.

(2) When the ALI (and the associated DAC) is determined by the non-stochastic 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), (the stochastic ALI) is listed in parentheses in Table I of Appendix B to Part D. In this case, the licensee or registrant may, as a simplifying assumption, use the stochastic ALIs to determine committed effective dose equivalent. However, if the licensee or registrant uses the stochastic ALIs, the licensee or registrant must also demonstrate that the limit in D.1201.A(1)(b) is met.

**1206. 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 D.1201 provided that each of the following conditions is satisfied:

A. 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.

B. 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.

C. Before a planned special exposure, the licensee or registrant ensures that each individual involved is:

(1) Informed of the purpose of the planned operation; and

(2) 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

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

D. Prior to permitting an individual to participate in a planned special exposure, the licensee or registrant ascertains prior doses as required by D.2104.B during the lifetime of the individual for each individual involved.

E. Subject to D.1201.B, 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:

(1) The numerical values of any of the dose limits in D.1201.A in any year; and

(2) Five times the annual dose limits in D.1201.A during the individual's lifetime.

F. The licensee or registrant maintains records of the conduct of a planned special exposure in accordance with D.2105 and submits a written report in accordance with D.2204.

G. 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 D.1201.A but shall be included in evaluations required by D.1206.D and E.

**1207. Occupational dose limits for minors**. The annual occupational dose limits for minors are 10 percent of the annual occupational dose limits specified for adult workers in D.1201.

**1208. Dose equivalent to an embryo/fetus.**

A. 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 5 mSv (0.5 rem). See D.2106 for record keeping requirements.

B. The licensee or registrant shall make efforts to avoid substantial variation[[1]](#footnote-1) above a uniform monthly exposure rate to a declared pregnant woman so as to satisfy the limit in D.1208.A.

C. The dose equivalent to an embryo/fetus shall be taken as the sum of:

(1) The deep-dose equivalent to the declared pregnant woman; and

(2) The dose equivalent to the embryo/fetus from radionuclides in the embryo/fetus and radionuclides in the declared pregnant woman.

D. If the dose equivalent to the embryo/fetus is found to have exceeded 0.5 rem (5 mSv), or is within 0.5 mSv (0.05 rem) of this dose, by the time the woman declares her pregnancy to the licensee or registrant, the licensee or registrant shall be deemed to be in compliance with paragraph A of this section if the additional dose equivalent does not exceed) 5mSv (0.05 rem) during the remainder of the pregnancy.

**SUBPART D - RADIATION DOSE LIMITS FOR INDIVIDUAL MEMBERS OF THE PUBLIC**

**1301. Dose limits for individual members of the public.**

A. Each licensee or registrant shall conduct operations so that:

(1) The Total effective dose equivalent to individual members of the public from the licensed or registered operation does not exceed 1 mSv (0.1 rem) in a year, exclusive of the dose contribution from background radiation, from any medical administration the individual has received, from exposure to individuals administered radioactive material and released in accordance with Part G, from voluntary participation in medical research programs, and from the licensee's or registrant's disposal of radioactive material into sanitary sewerage in accordance with D.2003[[2]](#footnote-2), and

(2) The dose in any unrestricted area from external sources, exclusive of the dose contributions from patients administered radioactive material and released in accordance with Part G, does not exceed 0.02 mSv (0.002 rem) in any one hour.

B. 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.

C. Notwithstanding paragraph A(1) of this section, a licensee may permit visitors to an individual who cannot be released in accordance with Part G, to receive a radiation dose greater than 1 mSv (0.1 rem) if:

(1) The radiation dose received does not exceed 5 mSv (0.5 rem); and

(2) The authorized user, as defined in Part G, has determined before the visit that it is appropriate.

D. 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 5 mSv (0.5 rem). This application shall include the following information:

(1) Demonstration of the need for and the expected duration of operations in excess of the limit in D.1301.A; and

(2) The licensee's or registrant's program to assess and control dose within the 5 mSv (0.5 rem) annual limit; and

(3) The procedures to be followed to maintain the dose ALARA.

E. In addition to the requirements of Part D, 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.

F. 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.

**1302. Compliance with dose Limits for individual members of the public.**

A. The licensee or registrant shall make or cause to be made 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 D.1301.

B. A licensee or registrant shall show compliance with the annual dose limit in D.1301 by:

D.1302.B(1)

(1) 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

(2) Demonstrating that:

(a) 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

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

C. 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.

**1310. Testing for leakage or contamination of sealed sources.**

A. The licensee or registrant in possession of any sealed source shall assure that:

(1) Each sealed source, except as specified in D.1310.B, is tested for leakage or contamination and the test results are received before the sealed source is put into use unless the licensee or registrant has a certificate from the transferor indicating that the sealed source was tested within six months before transfer to the licensee or registrant.

(2) 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 C.11.K(4) and (5) of this rule, an Agreement State or the Nuclear Regulatory Commission.

(3) 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 C.11.K(4) and (5) of this rule, an Agreement State or the Nuclear Regulatory Commission.

(4) 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 assure that the sealed source is tested for leakage or contamination before further use.

(5) Tests for leakage for all sealed sources, except brachytherapy sources manufactured to contain radium, shall be capable of detecting the presence of 185 Bq (0.005 μCi) 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.

(6) The test for leakage for brachytherapy sources manufactured to contain radium shall be capable of detecting an absolute leakage rate of 37 Bq (0.001 μCi) 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.

(7) 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 185 Bq (0.005 μCi) of a radium daughter which has a half-life greater than four days.

B. A licensee or registrant need not perform test for leakage or contamination on the following sealed sources:

(1) Sealed sources containing only radioactive material with a half-life of fewer than 30 days;

(2) Sealed sources containing only radioactive material as a gas;

(3) Sealed sources containing 3.7 MBq (100 μCi) or fewer of beta or photon- emitting material or 370 kBq (10 μCi) or fewer of alpha-emitting material;

(4) Sealed sources containing only hydrogen-3;

(5) Seeds of iridium-192 encased in nylon ribbon; and

(6) Sealed sources, except teletherapy and brachytherapy sources, which are stored, not being used and identified as in storage. The licensee or registrant 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.

C. Tests for leakage or contamination from sealed sources shall be performed by persons specifically authorized by the Agency, an Agreement State or the U.S. Nuclear Regulatory Commission to perform such services.

D. Test results shall be kept in units of becquerel or microcurie and maintained for inspection by the Agency.

E. The following shall be considered evidence that a sealed source is leaking:

(1) The presence of 185 Bq (0.005 μCi) or more of removable contamination on any test sample.

(2) Leakage of 37 Bq (0.001 μCi) of radon-222 per 24 hours for brachytherapy sources manufactured to contain radium.

(3) The presence of removable contamination resulting from the decay of 185 Bq (0.005 μCi) or more of radium.

F. The licensee or registrant 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 Part.

G. Reports of test results for leaking or contaminated sealed sources shall be made pursuant to D.2208.

**SUBPART E - RADIOLOGICAL CRITERIA FOR LICENSE TERMINATION**

**1401. General provisions and scope.** The criteria in this subpart apply to the decommissioning of facilities licensed under Parts C, E, G, K, and N of this rule.

A. The criteria in this subpart do not apply to sites which have been decommissioned prior to the effective date of this rule.

B. After a site has been decommissioned and the license terminated in accordance with the criteria in this subpart, the Agency will require additional cleanup only if, based on new information, it determines that the criteria of this subpart were not met and residual radioactivity remaining at the site could result in significant threat to public health and safety.

C. When calculating total effective dose equivalent 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.

D. Specific time limits for the completing the decommissioning process.

(1) Licensees shall complete decommissioning of the site or separate building or outdoor area as soon as practicable, but not later than 24 months following the initiation of decommissioning.

(2) When decommissioning involves the entire site, the licensee shall request license termination as soon as practicable but not later than 24 months following the initiation of decommissioning.

E. The Agency may approve a request for an alternative schedule for completion of the decommissioning of the site or separate building or outdoor area, and license termination is appropriate, if the Agency determines that the alternative is warranted.

**1402. 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 shall not exceed 10 mrem (0.10 mSv) per year, including that from groundwater sources of drinking water and the residual radioactivity has been reduced to levels that are as low as reasonably achievable (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.

**1403. Criteria for license termination under restricted conditions.** A site will be considered acceptable for license termination under restricted conditions if:

A. The licensee can demonstrate that further reductions in residual radioactivity necessary to comply with the provisions of D.1402. 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 deaths from transportation accidents, expected to potentially result from decontamination and waste disposal;

B. The licensee has made provisions for legally enforceable institutional controls that provide reasonable assurance that the total effective dose equivalent from residual radioactivity distinguishable from background to the average member of the critical group will not exceed 10 mrem (0.10 mSv) per year;

C. 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:

1) Funds placed into a trust segregated from the licensee’s assets and outside the licensee’s administrative control, and in which the adequacy of the trust funds is to be assessed based on an assumed one percent real rate of return on investment;

(2) A statement of intent in the case of State, or local Government licensees, as described in Part C.8.F; or

(3) When a governmental entity is assuming custody and ownership of a site, an arrangement that is deemed acceptable by such governmental entity;

D. 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 Parts C, D, and E, 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.

(1) 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:

(i) Will provide reasonable assurance that the TEDE from residual radioactivity distinguishable from background to the average member of the critical group will not exceed 10 mrem (0.10 mSv) TEDE per year;

(ii) Will be enforceable; and

(iii) Will not impose undue burdens on the local community or other affected parties.

(b) Whether the licensee has provided sufficient financial assurance to enable a third party, including a governmental custodian of a site, to assume and carry out responsibilities for any necessary control and maintenance of the site;

(2) In seeking advice on the issues identified in 1403.D(1), the licensee shall provide for:

(a) Participation by representatives of a broad cross section of community interests who may be affected by the decommissioning;

(b) An opportunity for a comprehensive, collective discussion on the issues by the participants represented; and

(c) 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

E. 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:

(1) 1mSv (100 mrem) per year; or

(2) 5MsV (500 mrem) per year provided the licensee:

(a) Demonstrates that further reductions in residual radioactivity necessary to comply with the 100 mrem/yr (1 mSv/yr) value of paragraph E(1) of this section are not technically achievable, would be prohibitively expensive, or would result in net public or environmental harm;

(b) Makes provisions for durable institutional controls; and

(c) 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 three years to assure that the institutional controls remain in place as necessary to meet the criteria of D.1403.B. and to assume and carry out responsibilities for any necessary control and maintenance of those controls. Acceptable financial assurance mechanisms are those in paragraph C. of this section.

**1404. Alternate criteria for license termination**

A. The Agency may terminate a license using alternate criteria greater than the dose criterion of parts D.1402, D.1403.B, and D.1403.D, if the licensee:

(1) 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 1 mSv/y (100 mrem/y) limit, by submitting an analysis of possible sources of exposure;

(2) Has employed to the extent practical restrictions on the site use according to the provisions of D.1403 in minimizing exposures at the site; and

(3) Reduces doses to ALARA levels, taking into consideration any detriments such as traffic accidents expected to potentially result from decontamination and waste disposal.

(4) Has submitted a decommissioning plan or license termination plan to the Agency indicating the licensee’s intent to decommission in accordance with Parts C, D, and E., 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 license shall provide for:

(a) Participation by representatives of a broad cross section of community interests who may be affected by the decommissioning;

(b) An opportunity for a comprehensive, collective discussion on the issues by the participants represented; and

(c) 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.

(5) Has provided sufficient financial assurance in the form of a trust fund 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.

B. The use of alternate criteria to terminate a license requires the approval of the Agency after consideration of the Agency’s staff’s recommendations that will address any comments by other appropriate agencies and any public comments submitted pursuant to D.2302.

**SUBPART F - SURVEYS AND MONITORING**

**1501. General.**

A. Each licensee shall make, or cause to be made, surveys of areas, including the subsurface, that:

(1) Are necessary for the licensee or registrant to comply with Part D; and

(2) Are necessary under the circumstances to evaluate:

(a) The magnitude of radiation levels; and

(b) Concentrations or quantities of residual radioactivity; and

(c) The potential radiological hazards of the radiation levels and residual radioactivity detected.

B. Notwithstanding D.2103.A of this part, records from surveys describing the location and amount of subsurface residual radioactivity identified at the site must be kept with records for decommissioning, and such records must be retained in accordance with C.25, C.8.F(7)(f), as applicable.

C. 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.

D. 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 D.1201, with other applicable provisions of this rule, or with conditions specified in a license or registration shall be processed and evaluated by a dosimetry processor.

E. The licensee or registrant shall ensure that adequate precautions are taken to prevent a deceptive exposure of an individual monitoring device.

**1502. 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 Part D. As a minimum:

A. Each licensee or registrant shall monitor occupational exposure to radiation from licensed and unlicensed radiation sources under the control of the licensee and shall supply and require the use of individual monitoring devices by:

(1) Adults likely to receive, in one year from sources external to the body, a dose in excess of 10 percent of the limits in D.1201.A; and

(2) Minors likely to receive, in one year from sources external to the body, a deep-dose equivalent in excess of 1 mSv (0.1 rem), a lens dose equivalent in excess of 1.5 mSv (0.15 rem), or a shallow dose equivalent to the skin or to the extremities in excess of 5 mSv (0.5 rem; and

(3) Declared pregnant women likely to receive during the entire pregnancy from sources external to the body, a deep-dose equivalent in excess of 1 mSv (0.1 rem; and

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

B. Each licensee or registrant shall monitor, to determine compliance with D.1204, the occupational intake of radioactive material by and assess the committed effective dose equivalent to:

(1) 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; and

(2) Minors and declared pregnant women (during the entire pregnancy) likely to receive, a committed effective dose equivalent in excess of 1 mSv (0.1 rem).

**SUBPART G - CONTROL OF EXPOSURE FROM EXTERNAL SOURCES**

**IN RESTRICTED AREAS**

**1601. Control of access to high radiation areas.**

A. 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:

(1) 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 1 mSv (0.1 rem) in one hour at 30 centimeters from the source of radiation or from any surface that the radiation penetrates; or

(2) 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

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

B. In place of the controls required by D.1601.A for a high radiation area, the licensee or registrant may substitute continuous direct or electronic surveillance that is capable of preventing unauthorized entry.

C. The licensee or registrant may apply to the Agency for approval of alternative methods for controlling access to high radiation areas.

D. The licensee or registrant shall establish the controls required by D.1601.A and C in a way that does not prevent individuals from leaving a high radiation area.

E. The licensee or registrant 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 regulations of the U.S. Department of Transportation provided that:

(1) The packages do not remain in the area longer than three days; and

(2) The dose rate at 1 meter from the external surface of any package does not exceed 0.1 mSv (0.01 rem) per hour.

F. The licensee or registrant 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 Part D and to operate within the ALARA provisions of the licensee's or registrant's radiation protection program.

G. The 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 D.1601 if the registrant has met all the specific requirements for access and control specified in other applicable Parts of this rule, such as, Part E for industrial radiography, Part F for x-rays in the healing arts, and Part I for particle accelerators.

**1602. Control of access to very high radiation areas.**

A. In addition to the requirements in D.1601, 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 5 Gy (500 rad) or more in one 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.

B. 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 D.1602.A if the registrant has met all the specific requirements for access and control specified in other applicable Parts of this rule, such as, Part E for industrial radiography, Part F for x-rays in the healing arts, and Part I for particle accelerators.

**1603. Control of access to very high radiation areas -- irradiators.**

A. Section D.1603 applies to licensees or registrants with sources of radiation in non-self-shielded irradiators. Section D.1603 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.

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

(1) Each entrance or access point shall be equipped with entry control devices which:

(a) Function automatically to prevent any individual from inadvertently entering a very high radiation area; and

(b) 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 1 mSv (0.1 rem) in one hour; and

(c) 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 1 mSv (0.1 rem) in one hour.

(2) Additional control devices shall be provided so that, upon failure of the entry control devices to function as required by D.1603.B(1):

(a) 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 1 mSv (0.1 rem) in one hour; and

(b) 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.

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

(a) 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 1 mSv (0.1 rem) in one hour; and

(b) Conspicuous visible and audible alarm signals are generated to make potentially affected individuals aware of the hazard and the licensee or registrant 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.

(4) When the shield for stored sealed sources is a liquid, the licensee or registrant shall provide means to monitor the integrity of the shield and to signal, automatically, loss of adequate shielding.

(5) 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 D.1603.B(3) and (4).

(6) 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.

(7) 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.

(8) 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 1 mSv (0.1 rem) in one hour.

(9) The entry control devices required in D.1603.B(1) shall be tested for proper functioning. See D.2109 for record keeping requirements.

(a) 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

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

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

(10) 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.

(11) 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 automatically to prevent loose radioactive material from being carried out of the area.

C. Licensees, registrants, or applicants for licenses or registrations for sources of radiation within the purview of D.1603.B 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 D.1603.B, 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 D.1603.B. 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.

D. The entry control devices required by D.1603.B and C shall be established in such a way that no individual will be prevented from leaving the area.

**SUBPART H - RESPIRATORY PROTECTION AND**

**CONTROLS TO RESTRICT INTERNAL EXPOSURE IN RESTRICTED AREAS**

**1701. Use of process or other engineering controls.** The licensee or registrant shall use, to the extent practicable, process or other engineering controls, such as, containment, decontamination or ventilation, to control the concentrations of radioactive material in air.

**1702. Use of other controls.**

A. 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 or registrant shall, consistent with maintaining the total effective dose equivalent ALARA, increase monitoring and limit intakes by one or more of the following means:

(1) Control of access; or

(2) Limitation of exposure times; or

(3) Use of respiratory protection equipment; or

(4) Other controls.

B. 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.

**1703. Use of individual respiratory protection equipment.**

A. If the licensee or registrant assigns or permits the use respiratory protection equipment to limit the intake of radioactive material pursuant to D.1702,

(1) Except as provided in D.1704.A(2), the licensee or registrant shall use only respiratory protection equipment that is tested and certified by the National Institute for Occupational Safety and Health (NIOSH).

(2) If the licensee or registrant wishes to use equipment that has not been tested or certified by the National Institute for Occupational Safety and Health, the licensee or registrant 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. This must be demonstrated either by licensee testing or on the basis of reliable test information.

(3) The licensee or registrant shall implement and maintain a respiratory protection program that includes:

(a) Air sampling sufficient to identify the potential hazard, permit proper equipment selection, and estimate doses; Note: In those cases where air sampling is difficult or even impossible, the exposure can be calculated based upon the known chemicals and ventilation rates;

(b) Surveys and bioassays, as appropriate, to evaluate actual intakes;

(c) Testing of respirators for operability (user seal check for face sealing devices and functional check for others) immediately prior to each use;

(d) Written procedures regarding respirator selection, fit testing, storage, issuance, maintenance, repair, testing of respirators, including testing for operability immediately prior to each use; quality assurance of respiratory protection equipment supervision and training of respirator users; monitoring, including air sampling and bioassays; breathing air quality, inventory and control, and recordkeeping; and limitations on periods of respirator use and relief from respirator use; and

(e) Determination by a physician that the individual user is medically fit to use the respiratory protection equipment; before.

(i) The initial fitting of a face sealing respirator;

(ii) Before the first field use of non-face sealing respirators, and

(iii) Either every 12 months thereafter, or periodically at a frequency determined by a physician.

(f) Fit testing, with a fit factor ≥ 10 times the APF for negative pressure devices, and a fit factor ≥ 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.

(4) The licensee or registrant 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.

(5) The licensee or registrant shall use respiratory protection equipment within the equipment manufacturer's expressed limitations for type and mode of use and 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.

(6) Standby rescue persons are required whenever one-piece atmosphere-supplying suits, or any combination of supplied air respiratory protection device and personnel protective equipment are used from which an unaided individual would have difficulty extricating himself or herself. The standby 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 with the workers (visual, voice, signal line, telephone, radio, or other suitable means), and be immediately available to assist them 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.

(7) 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:

(a) Oxygen content (v/v) of 19.5-23.5%;

(b) Hydrocarbon (condensed) content of 5 milligrams per cubic meter or air or fewer;

(c) Carbon Monoxide (CO) content of 10 ppm or fewer;

(d) Carbon Dioxide content of 1,000 ppm or fewer; and

(e) Lack of noticeable odor

(9) 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 wearer, are present between the skin of the wearer’s face and the sealing surface of a tight-fitting respirator facepiece.

(10) In estimating 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 the 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.

**1704. Further restrictions on the use of respiratory protection equipment.** The Agency may impose restrictions in addition to the provisions of D.1702 and D.1703, and Appendix A of this Part, in order to:

A. Ensure that the respiratory protection program of the licensee is adequate to limit doses to individuals from intakes of radioactive materials consistent with maintaining total effective dose equivalent ALARA; and

B. Limit the extent to which a licensee may use respiratory protection equipment instead of process or other engineering controls.

**1705. Application for use of higher assigned protection factors.** The licensee or registrant shall obtain authorization from the Agency before using assigned respiratory protection factors in excess of those specified in Appendix A. The Agency may authorize a licensee or registrant to use higher protection factors on receipt of an application that:

A. Describes the situation for which a need exists for higher protection factors, and

B. Demonstrates that the respiratory protection equipment provides these higher protection factors under the proposed conditions of use.

**SUBPART I - STORAGE AND CONTROL OF LICENSED**

**OR REGISTERED SOURCES OF RADIATION**

**1801. Security of stored sources of radiation.** The licensee or registrant shall secure from unauthorized removal or access licensed or registered sources of radiation that are stored in controlled or unrestricted areas.

**1802. Control of sources of radiation not in storage**

A. The licensee or registrant shall control and maintain constant surveillance of licensed or registered radioactive material that is in a controlled or unrestricted area and that is not in storage.

B. The registrant shall maintain control of radiation machines that are in a controlled or unrestricted area and that are not in storage.

**SUBPART J - PRECAUTIONARY PROCEDURES**

**1901. Caution Signs.**

A. Standard Radiation Symbol. Unless otherwise authorized by the Agency, the symbol prescribed by D.1901 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.



B. Exception to color requirements for standard radiation symbol. Notwithstanding the requirements of D.1901.A, licensees or registrants 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.

C. Additional information on signs and labels. In addition to the contents of signs and labels prescribed in Part D, 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.

**1902. Posting requirements**

A. 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**."

B. 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**."

C. 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**."

D. Posting of airborne radioactivity areas. The licensee or registrant 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**."

E. Posting of areas or rooms in which licensed or registered material is used or stored. The licensee or registrant shall post each area or room in which there is used or stored an amount of licensed or registered material exceeding 10 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)**."

**1903. Exceptions to posting requirements.**

A. A licensee or registrant is not required to post caution signs in areas or rooms containing sources of radiation for periods of fewer than eight hours, if each of the following conditions is met:

(1) 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 Part D; and

(2) The area or room is subject to the licensee's or registrant's control.

B. Rooms or other areas in hospitals that are occupied by patients are not required to be posted with caution signs pursuant to D.1902 provided that the patient could be released from confinement pursuant to Part G of this rule.

C. 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 0.05 mSv (0.005 rem) per hour.

D. Rooms in hospitals or clinics that are used for teletherapy are exempt from the requirement to post caution signs under D.1902 if:

(1) Access to the room is controlled pursuant to G.604; and

(2) Personnel in attendance take necessary precautions to prevent the inadvertent exposure of workers, other patients, and members of the public to radiation in excess of the limits established in this part.

E. 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 in the healing arts.

**1904. Labeling containers and radiation machines.**

A. The licensee or registrant shall ensure that each container of licensed or registered 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.

B. Each licensee or registrant 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.

C. 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.

**1905. Exemptions to labeling requirements.** A licensee or registrant is not required to label:

A. Containers holding licensed or registered material in quantities less than the quantities listed in Appendix C; or

B. Containers holding licensed or registered material in concentrations less than those specified in Table III of Appendix B; or

C. Containers attended by an individual who takes the precautions necessary to prevent the exposure of individuals in excess of the limits established by Part D; or

D. Containers when they are in transport and packaged and labeled in accordance with the regulations of the U.S. Department of Transportation[[3]](#footnote-3); or

E. 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

F. Installed manufacturing or process equipment, such as piping and tanks.

**1906. Procedures for receiving and opening packages.**

A. Each licensee or registrant who expects to receive a package containing quantities of radioactive material in excess of a Type A quantity, as defined in L.2 and Appendix A of Part L of this rule, shall make arrangements to receive:

(1) The package when the carrier offers it for delivery; or

(2) The notification of the arrival of the package at the carrier's terminal and to take possession of the package expeditiously.

B. Each licensee or registrant shall:

(1) Monitor the external surfaces of a labeled5/package for radioactive contamination unless the package contains only radioactive material in the form of gas or in special form as defined in A.2 of this rule; and

(2) Monitor the external surfaces of a labeled[[4]](#footnote-4) package for radiation levels unless the package contains quantities of radioactive material that are less than or equal to the Type A quantity, as defined in Part L of this rule; and

(3) 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.

C. The licensee or registrant shall perform the monitoring required by D.1906.B as soon as practicable after receipt of the package, but not later than three hours after the package is received at the licensee's or registrant's facility if it is received during the licensee's or registrant'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.

D. The licensee or registrant shall immediately notify the final delivery carrier and the Agency by telephone and telegram, mailgram, or facsimile, when:

(1) Removable radioactive surface contamination exceeds the limits of Part L of this rule; or

(2) External radiation levels exceed the limits of Part L of this rule.

E. Each licensee or registrant shall:

(1) Establish, maintain, and retain written procedures for safely opening packages in which radioactive material is received; and

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

F. Licensees or registrants 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 D.1906.B, but are not exempt from the monitoring requirement in D.1906.B for measuring radiation levels that ensures that the source is still properly lodged in its shield.

**SUBPART K - WASTE DISPOSAL**

**2001. General requirements.**

A. A licensee or registrant shall dispose of licensed or registered material only:

(1) By transfer to an authorized recipient as provided in D.2006, or in Part C of this rule, or to the U.S. Department of Energy; or

(2) By decay in storage; or

(3) By release in effluents within the limits in D.1301; or

(4) As authorized pursuant to D.2002, D.2003, D.2004, D.2005, or D.2008.

B. A person shall be specifically licensed or registered to receive waste containing licensed or registered material from other persons for:

(1) Treatment prior to disposal; or

(2) Treatment or disposal by incineration; or

(3) Decay in storage; or

(4) Disposal at a land disposal facility licensed pursuant to 10 CFR Part 61, Subpart B; or

(5) Storage until transferred to a storage or disposal facility authorized to receive the waste.

**2002. Method for obtaining approval of proposed disposal procedures.** A licensee or registrant or applicant for a license or registration may apply to the Agency for approval of proposed procedures, not otherwise authorized in this rule, to dispose of licensed or registered material generated in the licensee's or registrant's operations. Each application shall include:

A. A description of the waste containing licensed or registered 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

B. An analysis and evaluation of pertinent information on the nature of the environment; and

C. The nature and location of other potentially affected facilities; and

D. Analyses and procedures to ensure that doses are maintained ALARA and within the dose limits in Part D.

**2003. Disposal by release into sanitary sewerage**

A. A licensee or registrant may discharge licensed or registered material into sanitary sewerage if each of the following conditions is satisfied:

(1) The material is readily soluble, or is readily dispersible biological material, in water; and

(2) The quantity of licensed or registered radioactive material that the licensee or registrant releases into the sewer in one month divided by the average monthly volume of water released into the sewer by the licensee or registrant does not exceed the concentration listed in Table III of Appendix B; and

(3) If more than one radionuclide is released, the following conditions must also be satisfied:

(a) The licensee or registrant 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 or registrant into the sewer by the concentration of that radionuclide listed in Table III of Appendix B; and

(b) The sum of the fractions for each radionuclide required by D.2003.A(3)(a) does not exceed unity; and

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

B. Excreta from individuals undergoing medical diagnosis or therapy with radioactive material are not subject to the limitations contained in D.2003.A.

**2004. Treatment or disposal by incineration.** A licensee or registrant may treat or dispose of licensed or registered material by incineration only in the amounts and forms specified in D.2005 or as specifically approved by the Agency pursuant to D.2002.

**2005. Disposal of specific wastes.**

A. A licensee or registrant may dispose of the following licensed or registered material as if it were not radioactive:

(1) 1.85 kBq (0.05 μCi), or fewer, of hydrogen-3 or carbon-14 per gram of medium used for liquid scintillation counting; and

(2) 1.85 kBq (0.05 μCi), or fewer, of hydrogen-3 or carbon-14 per gram of animal tissue, averaged over the weight of the entire animal.

B. A licensee or registrant shall not dispose of tissue pursuant to D.2005.A(2) in a manner that would permit its use either as food for humans or as animal feed.

C. The licensee or registrant shall maintain records in accordance with D.2108.

**2006. Transfer for disposal and manifests.**

A. The requirements of D.2006, Appendices D and G of this Part are designed to control transfers of low-level radioactive waste by any waste generator, waste collector, or waste processor licensee, as defined, who ships low-level waste either directly or indirectly through a waste processor to a licensed low-level waste land disposal facility.

B. Each shipment of radioactive waste designated for disposal at a licensed low-level radioactive waste disposal facility shall be accompanied by a shipment manifest as specified in Section I of Appendix D.

C. Each shipment manifest shall include a certification by the waste generator as specified in Section III of Appendix D.

D. Each person involved in the transfer of waste for disposal or in the disposal of waste, including the waste generator, waste collector, waste processor, and disposal facility operator, shall comply with the requirements specified in Section IV of Appendix D.

E. Any license shipping radioactive material intended for ultimate disposal at a land disposal facility licensed under 10 CFR Part 61, Subpart B must document the information required on the NRC’s Uniform Low-Level Radioactive Waste Manifest and transfer this recorded manifest information to the intended consignee in accordance with Appendix D to this Part.

**2007. Compliance with environmental and health protection regulations.** Nothing in this Subpart 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 the Subpart.

**2008. Disposal of certain radioactive material**

A. Licensed material defined as;

(1) Any discrete source of radium-226 that is produced, extracted, or converted after extraction, before, on, or after August 8, 2005, for use for a commercial, medical, or research activity; or

(2) Any material that—

(a) Has been made radioactive by use of a particle accelerator; and

(b) Is produced, extracted, or converted after extraction, before, on, or after August 8, 2005, for use for a commercial, medical, or research activity; and

B. Any discrete source of naturally occurring radioactive material, other than source material, that—

(1) The NRC, in consultation with the Administrator of the Environmental Protection Agency, the Secretary of Energy, the Secretary of Homeland Security, and the head of any other appropriate federal agency, determines would pose a threat similar to the threat posed by a discrete source of radium-226 to the public health and safety or the common defense and security; and

(2) Before, on, or after August 8, 2005, is extracted or converted after extraction for use in a commercial, medical, or research activity.

C. A licensed material, as defined in paragraphs a and b of this section, may be disposed of in accordance with 10 CFR 61, even though it is not defined as low-level radioactive waste. Therefore, any licensed radioactive material being disposed of at a facility, or transferred for ultimate disposal at a facility licensed under 10 CFR 61, Subpart B must meet the requirements of D.2006.

D. A licensee may dispose of radioactive material, as defined in paragraphs a and b of this section at a disposal facility authorized to dispose of such material in accordance with any Federal or State solid or hazardous waste law, including the Solid Waste Disposal Act, as authorized under the Energy Policy Act of 2005, P.L. 109-58.

**SUBPART L – RECORDS**

**2101. General provisions.**

A. Each licensee or registrant shall use the units (curie, rad, rem and roentgen) including multiples and subdivisions, and shall clearly indicate the units of all quantities on records required by Part D.

B. In the records required by this Part, the licensee may record quantities in the International System of Units (SI) in parentheses following each of the units specified in paragraph A. However, all quantities must be recorded as stated in paragraph A.

C. Notwithstanding the requirements of paragraph A of this section, when recording information on shipment manifests, as required in D.2006, information must be recorded in SI units or in SI units and units as specified in paragraph A above.

D. The licensee or registrant shall make a clear distinction among the quantities entered on the records required by Part D, such as, total effective dose equivalent, total organ dose equivalent, shallow dose equivalent, lens dose equivalent, deep-dose equivalent, or committed effective dose equivalent.

**2102. Records of radiation protection programs.**

A. Each licensee or registrant shall maintain records of the radiation protection program, including:

(1) The provisions of the program; and

(2) Audits and other reviews of program content and implementation.

B. The licensee or registrant shall retain the records required by D.2102.A(1) until the Agency terminates each pertinent license or registration requiring the record. The licensee or registrant shall retain the records required by D.2102.A(2) for three years after the record is made.

**2103. Records of surveys.**

A. Each licensee or registrant shall maintain records showing the results of surveys and calibrations required by D.1501 and D.1906.B. The licensee or registrant shall retain these records for three years after the record is made.

B. The licensee or registrant shall retain each of the following records until the Agency terminates each pertinent license or registration requiring the record:

(1) 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

(2) 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

(3) Records showing the results of air sampling, surveys, and bioassays required pursuant to D.1703.A(3)(a) and (b); and

(4) Records of the results of measurements and calculations used to evaluate the release of radioactive effluents to the environment.

C. Upon termination of the license or registration, the licensee or registrant shall permanently store records on HHE-835 or equivalent, or shall make provision with the Agency for transfer to the Agency.

**2104. Determination and records of prior occupational dose.**

A. For each individual who is likely to receive, in a year, an occupational dose requiring monitoring pursuant to D.1502, the licensee or registrant shall:

(1) Determine the occupational radiation dose received during the current year; and

(2) Attempt to obtain the records of cumulative occupational radiation dose.

B. Prior to permitting an individual to participate in a planned special exposure, the licensee or registrant shall determine:

(1) The internal and external doses from all previous planned special exposures;

(2) All doses in excess of the limits, including doses received during accidents and emergencies, received during the lifetime of the individual; and

(3) All cumulative occupational radiation dose.

C. In complying with the requirements of D.2104.A, a licensee or registrant may:

(1) 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

(2) Accept, as the record of cumulative radiation dose, an up-to-date Agency form HHE 835 or equivalent, 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;

(3) 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.

D. The licensee or registrant shall record the exposure history, as required by D.2104.A, on Agency form HHE 835, or other clear and legible record, of all the information required on that form. 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.

(1) 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 HHE 835 or equivalent. For any period in which the licensee or registrant does not obtain a report, the licensee or registrant shall place a notation on HHE 835 or equivalent indicating the periods of time for which data are not available.

(2) 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 regulations in Part D in effect before January 1, 1994. Further, occupational exposure histories obtained and recorded on HHE 835 or equivalent 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.

E. 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:

(1) In establishing administrative controls pursuant to D.1201.F. for the current year, that the allowable dose limit for the individual is reduced by 12.5 mSv (1.25 rem) for each quarter for which records were unavailable and the individual was engaged in activities that could have resulted in occupational radiation exposure; and

(2) That the individual is not available for planned special exposures.

F. The licensee or registrant shall retain the records of prior occupational dose and exposure history as specified in D.2104 on HHE 835 or equivalent until the Agency terminates each pertinent license or registration requiring this record. The licensee or registrant shall retain records used in preparing HHE 835 or equivalent for three years after the record is made.

G. Upon termination of the license or registration, the licensee or registrant shall permanently store records on HHE-835 or equivalent, or shall make provision with the Agency for transfer to the Agency.

**2105. Records of planned special exposures.**

A. For each use of the provisions of D.1206 for planned special exposures, the licensee or registrant shall maintain records that describe:

(1) The exceptional circumstances requiring the use of a planned special exposure;

(2) The name of the management official who authorized the planned special exposure and a copy of the signed authorization;

(3) What actions were necessary;

(4) Why the actions were necessary;

(5) What precautions were taken to assure that doses were maintained ALARA;

(6) What individual and collective doses were expected to result; and

(7) The doses actually received in the planned special exposure.

B. The licensee or registrant shall retain the records until the Agency terminates each pertinent license or registration requiring these records.

C. Upon termination of the license or registration, the licensee or registrant shall permanently store records on HHE-835 or equivalent, or shall make provision with the Agency for transfer to the Agency.

**2106. Records of individual monitoring results.**

A. Record keeping requirement. Each licensee or registrant shall maintain records of doses received by all individuals for whom monitoring was required pursuant to D.1502, and records of doses received during planned special exposures, accidents, and emergency conditions. Assessments of dose equivalent and records made using units in effect before January 1, 1994 need not be changed. These records shall include, when applicable:

(1) The deep-dose equivalent to the whole body, lens dose equivalent, shallow dose equivalent to the skin, and shallow dose equivalent to the extremities;

(2) The estimated intake of radionuclides, see D.1202;

(3) The committed effective dose equivalent assigned to the intake of radionuclides;

(4) The specific information used to calculate the committed effective dose equivalent pursuant to D.1204.C;

(5) The total effective dose equivalent when required by D.1202; and

(6) The total of the deep-dose equivalent and the committed dose to the organ receiving the highest total dose.

B. Record-keeping frequency. The licensee or registrant shall make entries of the records specified in D.2106.A at intervals not to exceed one year.

C. Record-keeping format. The licensee or registrant shall maintain the records specified in D.2106.A on HHE-840, in accordance with the instructions for HHE-840, or in clear and legible records containing all the information required by HHE-840.

D. 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.

E. The licensee or registrant shall retain each required form or record until the Agency terminates each pertinent license or registration requiring the record.

F. Upon termination of the license or registration, the licensee or registrant shall permanently store records on HHE-835 or equivalent, or shall make provision with the Agency for transfer to the Agency.

**2107. Records of dose to individual members of the public.**

A. Each licensee or registrant shall maintain records sufficient to demonstrate compliance with the dose limit for individual members of the public. See D.1301.

B. The licensee or registrant shall retain the records required by D.2107.A until the Agency terminates each pertinent license or registration requiring the record.

**2108. Records of waste disposal.**

A. Each licensee or registrant shall maintain records of the disposal of licensed or registered materials made pursuant to D.2002, D.2003, D.2004, or D.2006, of this rule, and disposal by burial in soil, including burials authorized before January 28, 1981.[[5]](#footnote-5)

B. The licensee or registrant shall retain the records required by D.2108.A until the Agency terminates each pertinent license or registration requiring the record.

**2109. Records of testing entry control devices for very high radiation areas.**

A. Each licensee or registrant shall maintain records of tests made pursuant to D.1603.B(9) on entry control devices for very high radiation areas. These records must include the date, time, and results of each such test of function.

B. The licensee or registrant shall retain the records required by D.2109.A for three years after the record is made.

**2110. Form of records.** Each record required by Part D 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 shall maintain adequate safeguards against tampering with and loss of records.

**2111. Records of tests for leakage or contamination of sealed sources.** Records of tests for leakage or contamination of sealed sources required by D.1310 shall be kept in units of becquerel or microcurie and maintained for inspection by the Agency for five years after the records are made.

**SUBPART M - REPORTS**

**2201. Reports of stolen, lost, or missing Licensed or registered sources of radiation.**

A. Telephone reports. Each licensee or registrant shall report to the Agency by telephone as follows:

(1) Immediately after its occurrence becomes known to the licensee or registrant, stolen, lost, or missing licensed or registered 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 or registrant that an exposure could result to individuals in unrestricted areas; or

(2) Within 30 days after its occurrence becomes known to the licensee or registrant, lost, stolen, or missing licensed or registered radioactive material in an aggregate quantity greater than 10 times the quantity specified in Appendix C that is still missing.

(3) Immediately after its occurrence becomes known to the registrant, a stolen, lost, or missing radiation machine.

B. Written reports. Each licensee required to make a report under D.2201.A shall, within 30 days after making the telephone report, make a written report setting forth the following information:

(1) 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;

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

(3) A statement of disposition, or probable disposition, of the licensed or registered source of radiation involved; and

(4) Exposures of individuals to radiation, circumstances under which the exposures occurred, and the possible total effective dose equivalent to persons in unrestricted areas; and

(5) Actions that have been taken, or will be taken, to recover the source of radiation; and

(6) 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.

C. 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.

D. The licensee or registrant shall prepare any report filed with the Agency pursuant to D.2201 so that names of individuals who may have received exposure to radiation are stated in a separate and detachable portion of the report.

**2202. Notification of incidents.**

A. 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:

(1) An individual to receive --

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

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

(c) A shallow-dose equivalent to the skin or extremities or a total organ dose equivalent of 2.5 Gy (250 rads) or more; or

(2) 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 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).

B. 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:

(1) An individual to receive, in a period of 24 hours:

(a) A total effective dose equivalent exceeding 0.05 Sv (5 rem); or

(b) A lens-dose equivalent exceeding 0.15 Sv (15 rem); or

(c) A shallow-dose equivalent to the skin or extremities or a total organ dose equivalent exceeding 0.5 Sv (50 rem); or

(2) 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. The provisions of this paragraph do not apply to locations where personnel are not normally stationed during routine operations, such as hot-cells or process enclosures.

C. The licensee or registrant shall prepare each report filed with the Agency pursuant to D.2202 so that names of individuals who have received exposure to sources of radiation are stated in a separate and detachable portion of the report.

D. Licensees or registrants shall make the reports required by D.2202.A and B to the Agency by telephone, telegram, mailgram, or facsimile to the Agency.

E. The provisions of D.2202 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 D.2204.

**2203. Reports of exposures, radiation levels, and concentrations of radioactive material exceeding the limits.**

A. Reportable events. In addition to the notification required by D.2202, each licensee or registrant shall submit a written report within 30 days after learning of any of the following occurrences:

(1) Incidents for which notification is required by D.2202; or

(2) Doses in excess of any of the following:

(a) The occupational dose limits for adults in D.1201;

(b) The occupational dose limits for a minor in D.1207;

(c) The limits for an embryo/fetus of a declared pregnant woman in D.1208;

(d) The limits for an individual member of the public in D.1301;

(e) Any applicable limit in the license or registration; or

(3) Levels of radiation or concentrations of radioactive material in:

(a) A restricted area in excess of applicable limits in the license or registration; or

(b) An unrestricted area in excess of 10 times the applicable limit set forth in Part D or in the license or registration, whether or not involving exposure of any individual in excess of the limits in D.1301; or

(4) 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.

B. Contents of reports.

(1) Each report required by D.2203.A shall describe the extent of exposure of individuals to radiation and radioactive material, including, as appropriate:

(a) Estimates of each individual's dose; and

(b) The levels of radiation and concentrations of radioactive material involved; and

(c) The cause of the elevated exposures, dose rates, or concentrations; and

(d) 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 or registration conditions.

(2) Each report filed pursuant to D.2203.A. shall include for each individual exposed: the name, Social Security number, and date of birth. With respect to the limit for the embryo/fetus in D.1208, 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 part of the report and must be clearly labeled “**Privacy Act Information: Not For Public Disclosure**.”

C. All licensees or registrants who make reports pursuant to D.2203.A shall submit the report in writing to the Agency.

**2204. 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 D.1206, informing the Agency that a planned special exposure was conducted and indicating the date the planned special exposure occurred and the information required by Sec. D.2105.

**2205. Reports to individuals of exceeding dose limits.** When a licensee is required, pursuant to D.2203, D.2204, or D.2206 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 shall also provide a report on his or her exposure data included in the report submitted to the Agency to the individual. This report must be transmitted at a time no later than the transmittal to the Agency.

**2206. Reports of individual monitoring.**

A. This section applies to each person licensed or registered by the Agency to:

1. Possess or use sources of radiation for purposes of industrial radiography pursuant to Parts C and E of this rule; or

(2) Possess or use at any time, for processing or manufacturing for distribution pursuant to Part C or G of this rule, radioactive material in quantities exceeding any one of the following quantities:

Radionuclide Activitya

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.

a The Agency may require as a license condition, or by rule, regulation, or order, 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.

B. Each licensee or registrant in a category listed in D.2206.A 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 D.1502 during that year. The licensee or registrant may include additional data for individuals for whom monitoring was provided but not required. The licensee or registrant shall use HHE-840 or equivalent or electronic media containing all the information required by HHE-840.

C. The licensee or registrant shall file the report required by D.2206.B, covering the preceding year, on or before April 30 of each year. The licensee or registrant shall submit the report to the Agency.

**2207. 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 paragraphs (a) through (e) of this section for each type of transaction.

A. Each licensee who manufactures a nationally tracked source shall complete and submit a National Source Tracking Transaction Report. The report must include the following information:

(1) The name, address, and license number of the reporting licensee;

(2) The name of the individual preparing the report;

(3) The manufacturer, model, and serial number of the source;

(4) The radioactive material in the source;

(5) The initial source strength in becquerels (curies) at the time of manufacture; and

(6) The manufacture date of the source.

B. 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:

(1) The name, address, and license number of the reporting licensee;

(2) The name of the individual preparing the report;

(3) The name and license number of the recipient facility and the shipping address;

(4) The manufacturer, model, and serial number of the source or, if not available, other information to uniquely identify the source;

(5) The radioactive material in the source;

(6) The initial or current source strength in becquerels (curies);

(7) The date for which the source strength is reported;

(8) The shipping date;

(9) The estimated arrival date; and

(10) For nationally tracked sources transferred as waste under a Uniform Low-Level Radioactive Waste Manifest, the waste manifest number and the container identification of the container with the nationally tracked source

C. 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:

(1) The name, address, and license number of the reporting licensee;

(2) The name of the individual preparing the report;

(3) The name, address, and license number of the person that provided the source;

(4) The manufacturer, model, and serial number of the source or, if not available, other information to uniquely identify the source;

(5) The radioactive material in the source;

(6) The initial or current source strength in becquerels (curies);

(7) The date for which the source strength is reported;

(8) The date of receipt; and

(9) For material received under a Uniform Low-Level Radioactive Waste Manifest, the waste manifest number and the container identification with the nationally tracked source.

D. 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:

(1) The name, address, and license number of the reporting licensee;

(2) The name of the individual preparing the report;

(3) The manufacturer, model, and serial number of the source or, if not available, other information to uniquely identify the source;

(4) The radioactive material in the source;

(5) The initial or current source strength in becquerels (curies);

(6) The date for which the source strength is reported; and

(7) The disassemble date of the source.

E. Each Licensee who disposes of nationally tracked source shall complete and submit a National Source Tracking Transaction Report. The report must include the following information:

(1) The name, address, and license number of the reporting licensee;

(2) The name of the individual preparing the report;

(3) The waste manifest number;

(4) The container identification with the nationally tracked source;

(5) The date of disposal; and

(6) The method of disposal.

F. The reports discussed in paragraphs A through E of this section 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:

(1) The on-line National Source Tracking System;

(2) Electronically using a computer-readable format;

(3) By facsimile;

(4) By mail to the address on the National Source Tracking Transaction Report Form (NRC Form 748); or

(5) By telephone with follow up by facsimile or mail.

G. 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 paragraphs A through E of this section. 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.

**2208. Notifications and reports to individuals**.

A. Requirements for notification and reports to individuals of exposure to radiation or radioactive material are specified in J.4 of this rule.

B. When a licensee or registrant is required pursuant to D.2203 to report to the Agency any exposure of an individual to radiation or radioactive material, the licensee or registrant shall also notify 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 J.4.A of this rule.

**2209. Reports of leaking or contaminated sealed sources.** The licensee or registrant shall file a report within five days with the Agency if the test for leakage or contamination required pursuant to D.1310 indicates a sealed source is leaking or contaminated. The report shall include the equipment involved, the test results and the corrective action taken.

**ADDITIONAL REQUIREMENTS**

**2301. Vacating premises.** Each specific licensee or registrant shall, no fewer than 30 days before vacating or relinquishing possession or control of premises which may have been contaminated with radioactive material as a result of his 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.

**2302. 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 D.1402 and D.1403, or whenever the Agency deems such notice to be in the public interest, the Agency shall:

A. Notify and solicit comments from:

(1) Local 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) Other appropriate agencies for cases where the licensee proposes to release a site pursuant to D.1403.

B. Publish a notice 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.

**2304. Minimization of contamination.**

A. Applicants for licenses, 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.

B. Licensees shall, to the extent practical, conduct operations to minimize the introduction of residual radioactivity into the site, including the subsurface, in accordance with the existing radiation protection requirements in Subpart B and radiological criteria for license termination in Subpart E of this part.

**APPENDIX A**

ASSIGNED PROTECTION FACTORS FOR RESPIRATORA

|  |  |  |
| --- | --- | --- |
|  | Operating Mode | Assigned Protection Factors |
| 1. Air purifying respirators (Particulateb only)c   Filtering faceplate disposabled ------  Facepiece, halfe------------------------  Facepiece, full-------------------------  Facepiece, half-------------------------  Facepiece, full-------------------------  Helmet/hood---------------------------  Facepiece, loose fitting--------------- | Negative pressure--------------- Negative pressure--------------- Negative pressure--------------- Powered air-purifying respirators- Powered air-purifying respirators- Powered air-purifying respirators- Powered air-purifying respirators- | (d) 10 100 50 1000 1000 25 |
| 1. Atmosphere supplying respirators (Particulate, gases, and vaporsf)   1: Air-line respirator:  Facepiece, half-----------------------  Facepiece, halfe----------------------  Facepiece, half-----------------------  Facepiece, full------------------------  Facepiece, full------------------------  Facepiece, full------------------------  Helmet/hood--------------------------  Facepiece, loose fitting-------------  Suit------------------------------------  2: Self-contained breathing apparatus (SCBA): Facepiece, full----------------------- Facepiece, full----------------------- Facepiece, full----------------------- Facepiece, full----------------------- | Demand--------------------------- Continuous flow---------------- Pressure demand---------------- Demand--------------------------- Continuous flow---------------- Pressure demand---------------- Continuous flow---------------- Continuous flow---------------- Continuous flow----------------  Demand--------------------------- Pressure demand----------------- Demand, recirculating------------ Positive pressure recirculating--- | 10 50 50 100 1000 1000 1000 25 (g)  h100 i10,000 h100 i10,000 |
| 1. Combination respirators:   Any combination of air-purifying and atmosphere-supplying respirators | Assigned protection factor for type and mode of operations as listed above | |

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a-i See the following pages for footnotes.

**Appendix A.**

a. These assigned protection factors apply only in respiratory protection program that meets the requirements of this Part. 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 1, column 3 of Appendix B to Part D 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.

b. 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 area at least 99 percent efficient. Air purifying respirators with APF >100 must be equipped with particulate filters that area at least 99.97 percent efficient.

c. 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).

d. 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 their 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 D.1703 and 10 CFR Part 20, Appendix A. 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.

e. 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 this Part are met.

f. 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 one0third 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.

g. No NIOSH approval schedule is currently available for atmospheric supplying units. 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 (i.e., D.24).

h. The licensee should implement institutional controls to assure that these devices are not used in areas immediately dangerous to life or health (IDLH).

i. 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.

**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**

**1. 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 mm, 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 fewer 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 x 10-2 or 0.06, 6E+2 represents 6 x 102 or 600, and 6E+0 represents 6 x 100 or 6.***

**2. 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 Man which would result in either (1) a committed effective dose equivalent of 0.05 Sv (5 rem), stochastic ALI, or (2) a committed dose equivalent of 0.5 Sv (50 rem) to an organ or tissue, non-stochastic 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 0.05 Sv (5 rem). The derivation includes multiplying the committed dose equivalent to an organ or tissue by a weighting factor, WT. 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 WT are listed under the definition of weighting factor in Part D.3. The non-stochastic ALIs were derived to avoid non-stochastic effects, such as prompt damage to tissue or reduction in organ function.

A value of WT = 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.

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.

When an ALI is defined by the stochastic dose limit, this value alone is given. When an ALI is determined by the non-stochastic 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 non-stochastic ALIs, will ensure that non-stochastic 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 non-stochastic ALI is limiting, use of that non-stochastic 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 0.5 Sv (50 rem) 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 non-stochastic ALIs (ALIns) that contribute to the committed dose equivalent to the organ receiving the highest dose does not exceed unity, that is, (intake (in ∏Ci) of each radionuclide/ALIns) < 1.0. If there is an external deep-dose equivalent contribution of Hd, then this sum must be less than 1 - (Hd/50), instead of < 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(in mCi)/(2000 hours per working year x 60 minutes/hour x 2 x 104 ml per minute) = [ALI/2.4 x 109] mCi/ml, where 2 x 104 ml is the volume of air breathed per minute at work by Reference Man 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 D.7. 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.

**3. 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 D.15. 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 0.5 mSv (0.05 rem).

Consideration of non-stochastic limits has not been included in deriving the air and water effluent concentration limits because non-stochastic effects are presumed not to occur at or below the dose levels established for individual members of the public. For radionuclides, where the non-stochastic 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.

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 x 109, 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 0.05 Sv (5 rem) annual occupational dose limit to the 1 mSv (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 x 107. The factor of 7.3 x 107 (ml) includes the following components: the factors of 50 and 2 described above and a factor of 7.3 x 105 (ml), which is the annual water intake of Reference Man.

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.

**4. Table III, Releases to Sewers**

The monthly average concentrations for release to sanitary sewerage are applicable to the provisions in D.35. The concentration values were derived by taking the most restrictive occupational stochastic oral ingestion ALI and dividing by 7.3 x 106 (ml). The factor of 7.3 x 106 (ml) is composed of a factor of 7.3 x 105 (ml), the annual water intake by Reference Man, 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 Man during a year, would result in a committed effective dose equivalent of 5 mSv (0.5 rem).

**LIST OF ELEMENTS**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Name | Symbol | Atomic number | Name | Symbol | Atomic Number |
| Actinium | Ac | 89 | Molybdenum | Mo | 42 |
| Aluminum | Al | 13 | Neodymium | Nd | 60 |
| Americium | Am | 95 | Neptunium | Np | 93 |
| Antimony | Sb | 51 | Nickel | Ni | 28 |
| Argon | Ar | 18 | Niobium | Nb | 41 |
| Arsenic | As | 33 | Nitrogen | N | 7 |
| Astatine | At | 85 | Osmium | Os | 76 |
| Barium | Ba | 56 | Oxygen | O | 8 |
| Berkelium | Bk | 97 | Palladium | Pd | 46 |
| Beryllium | Be | 4 | Phosphorus | P | 15 |
| Bismuth | Bi | 83 | Platinum | Pt | 78 |
| Bromine | Br | 35 | Plutonium | Pu | 94 |
| Cadmium | Cd | 48 | Polonium | Po | 84 |
| Calcium | Ca | 20 | Potassium | K | 19 |
| Californium | Cf | 98 | Praseodymium | Pr | 59 |
| Carbon | C | 6 | Promethium | Pm | 61 |
| Cerium | Ce | 58 | Protactinium | Pa | 91 |
| Cesium | Cs | 55 | Radium | Ra | 88 |
| Chlorine | Cl | 17 | Radon | Rn | 86 |
| Chromium | Cr | 24 | Rhenium | Re | 75 |
| Cobalt | Co | 27 | Rhodium | Rh | 45 |
| Copper | Cu | 29 | Rubidium | Rb | 37 |
| Curium | Cm | 96 | Ruthenium | Ru | 44 |
| Dysprosium | Dy | 66 | Samarium | Sm | 62 |
| Einsteinium | Es | 99 | Scandium | Sc | 21 |
| Erbium | Er | 68 | Selenium | Se | 34 |
| Europium | Eu | 63 | Silicon | Si | 14 |
| Fermium | Fm | 100 | Silver | Ag | 47 |
| Fluorine | F | 9 | Sodium | Na | 11 |
| Francium | Fr | 87 | Strontium | Sr | 38 |
| Gadolinium | Gd | 64 | Sulfur | S | 16 |
| Gallium | Ga | 31 | Tantalum | Ta | 73 |
| Germanium | Ge | 32 | Technetium | Tc | 43 |
| Gold | Au | 79 | Tellurium | Te | 52 |
| Hafnium | Hf | 72 | Terbium | Tb | 65 |
| Holmium | Ho | 67 | Thallium | Tl | 81 |
| Hydrogen | H | 1 | Thorium | Th | 90 |
| Indium | In | 49 | Thulium | Tm | 69 |
| Iodine | I | 53 | Tin | Sn | 50 |
| Iridium | Ir | 77 | Titanium | Ti | 22 |
| Iron | Fe | 26 | Tungsten | W | 74 |
| Krypton | Kr | 36 | Uranium | U | 92 |
| Lanthanum | La | 57 | Vanadium | V | 23 |
| Lead | Pb | 82 | Xenon | Xe | 54 |
| Lutetium | Lu | 71 | Ytterbium | Yb | 70 |
| Magnesium | Mg | 12 | Yttrium | Y | 39 |
| Manganese | Mn | 25 | Zinc | Zn | 30 |
| Mendelevium | Md | 101 | Zirconium | Zr | 40 |
| Mercury | Hg | 80 |  |  |  |

Table I Table II Table III  
 Effluent Releases to  
 Occupational Values Concentrations Sewers

Col. 1 Col. 2 Col. 3 Col. 1 Col. 2  
 Oral Monthly  
 Ingestion Inhalation Average  
Atomic ALI ALI DAC Air Water Concentration  
No. Radionuclide Class (Ci) (Ci) (Ci/ml) (Ci/ml) (Ci/ml) (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 T2) Submersion1: Use above values

as HT and T2 oxidize in air and in the body to HTO.

4 Beryllium-7 W, all compounds except 4E+4 2E+4 9E-6 3E-8 6E-4 6E-3  
 those given for Y  
 Y, oxides, halides, and  
 nitrates - 2E+4 8E-6 3E-8 - -  
4 Beryllium-10 W, see 7Be 1E+3 2E+2 6E-8 2E-10 - -  
 LLI wall  
 (1E+3) - - - 2E-5 2E-4  
 Y, see 7Be - 1E+1 6E-9 2E-11 - -  
6 Carbon-112 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

7 Nitrogen-132 Submersion1 - - 4E-6 2E-8 - -

8 Oxygen-152 Submersion1 - - 4E-6 2E-8 - -

9 Fluorine-182 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 - -  
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 31Si 2E+3 2E+2 1E-7 3E-10 - -  
 LLI wall  
 (3E+3) - - - 4E-5 4E-4  
 W, see 31Si - 1E+2 5E-8 2E-10 - -  
 Y, see 31Si - 5E+0 2E-9 7E-12 - -  
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 Zn2+,  
 S3+, Mg2+, Fe3+, Bi3+,  
 and lanthanides - 4E+2 2E-7 5E-10 - -  
15 Phosphorus-33 D, see 32P 6E+3 8E+3 4E-6 1E-8 8E-5 8E-4  
 W, see 32P - 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, 6E+3  
 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 - 2E+3 9E-7 3E-9 - -

Table I Table II Table III  
 Effluent Releases to  
 Occupational Values Concentrations Sewers

Col. 1 Col. 2 Col. 3 Col. 1 Col. 2  
 Oral Monthly  
 Ingestion Inhalation Average  
Atomic ALI ALI DAC Air Water Concentration  
No. Radionuclide Class (Ci) (Ci) (Ci/ml) (Ci/ml) (Ci/ml) (Ci/ml)

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 lantha-  
 nides, 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 - -

17 Chlorine-382 D, see 36Cl 2E+4 4E+4 2E-5 6E-8 - -  
 St wall  
 (3E+4) - - - 3E-4 3E-3  
 W, see 36Cl - 5E+4 2E-5 6E-8 - -  
17 Chlorine-392 D, see 36Cl 2E+4 5E+4 2E-5 7E-8 - -  
 St wall  
 (4E+4) - - - 5E-4 5E-3  
 W, see 36Cl - 6E+4 2E-5 8E-8 - -  
18 Argon-37 Submersion1 - - 1E+0 6E-3 - -  
18 Argon-39 Submersion1 - - 2E-4 8E-7 - -  
18 Argon-41 Submersion1 - - 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-442 D, all compounds 2E+4 7E+4 3E-5 9E-8 - -  
 St wall  
 (4E+4) - - - 5E-4 5E-3  
19 Potassium-452 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 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-492 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, SrTi0 - 6E+0 2E-9 8E-12 - -  
22 Titanium-45 D, see 44Ti 9E+3 3E+4 1E-5 3E-8 1E-4 1E-3  
 W, see 44Ti - 4E+4 1E-5 5E-8 - -  
 Y, see 44Ti - 3E+4 1E-5 4E-8 - -  
23 Vanadium-472 D, all compounds except  
 those given for W 3E+4 8E+4 3E-5 1E-7 - -  
 St wall  
 (3E+4) - - - 4E-4 4E-3  
 W, oxides, hydroxides,  
 carbides, and halides - 1E+5 4E-5 1E-7 - -  
23 Vanadium-48 D, see 47V 6E+2 1E+3 5E-7 2E-9 9E-6 9E-5  
 W, see 47V - 6E+2 3E-7 9E-10 - -  
23 Vanadium-49 D, see 47V 7E+4 3E+4 1E-5 - - -  
 LLI wall Bone surf  
 (9E+4) (3E+4) - 5E-8 1E-3 1E-2  
 W, see 47V - 2E+4 8E-6 2E-8 - -  
24 Chromium-48 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-492 D, see 48Cr 3E+4 8E+4 4E-5 1E-7 4E-4 4E-3  
 W, see 48Cr - 1E+5 4E-5 1E-7 - -  
 Y, see 48Cr - 9E+4 4E-5 1E-7 - -

24 Chromium-51 D, see 48Cr 4E+4 5E+4 2E-5 6E-8 5E-4 5E-3  
 W, see 48Cr - 2E+4 1E-5 3E-8 - -  
 Y, see 48Cr - 2E+4 8E-6 3E-8 - -

25 Manganese-512 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 - -

Table I Table II Table III  
 Effluent Releases to  
 Occupational Values Concentrations Sewers

Col. 1 Col. 2 Col. 3 Col. 1 Col. 2  
 Oral Monthly  
 Ingestion Inhalation Average  
Atomic ALI ALI DAC Air Water Concentration  
No. Radionuclide Class (Ci) (Ci) (Ci/ml) (Ci/ml) (Ci/ml) (Ci/ml)

25 Manganese-52m2 D, see 51Mn 3E+4 9E+4 4E-5 1E-7 - -  
 St wall  
 (4E+4) - - - 5E-4 5E-3  
 W, see 51Mn - 1E+5 4E-5 1E-7 - -  
25 Manganese-52 D, see 51Mn 7E+2 1E+3 5E-7 2E-9 1E-5 1E-4  
 W, see 51Mn - 9E+2 4E-7 1E-9 - -  
25 Manganese-53 D, see 51Mn 5E+4 1E+4 5E-6 - 7E-4 7E-3  
 Bone surf  
 - (2E+4) - 3E-8 - -  
 W, see 51Mn - 1E+4 5E-6 2E-8 - -  
25 Manganese-54 D, see 51Mn 2E+3 9E+2 4E-7 1E-9 3E-5 3E-4  
 W, see 51Mn - 8E+2 3E-7 1E-9 - -  
25 Manganese-56 D, see 51Mn 5E+3 2E+4 6E-6 2E-8 7E-5 7E-4  
 W, see 51Mn - 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 52Fe 9E+3 2E+3 8E-7 3E-9 1E-4 1E-3  
 W, see 52Fe - 4E+3 2E-6 6E-9 - -  
26 Iron-59 D, see 52Fe 8E+2 3E+2 1E-7 5E-10 1E-5 1E-4  
 W, see 52Fe - 5E+2 2E-7 7E-10 - -  
26 Iron-60 D, see 52Fe 3E+1 6E+0 3E-9 9E-12 4E-7 4E-6  
 W, see 52Fe - 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 55Co 5E+2 3E+2 1E-7 4E-10 6E-6 6E-5  
 Y, see 55Co 4E+2 2E+2 8E-8 3E-10 - -  
27 Cobalt-57 W, see 55Co 8E+3 3E+3 1E-6 4E-9 6E-5 6E-4  
 Y, see 55Co 4E+3 7E+2 3E-7 9E-10 - -  
27 Cobalt-58m W, see 55Co 6E+4 9E+4 4E-5 1E-7 8E-4 8E-3  
 Y, see 55Co - 6E+4 3E-5 9E-8 - -  
27 Cobalt-58 W, see 55Co 2E+3 1E+3 5E-7 2E-9 2E-5 2E-4  
 Y, see 55Co 1E+3 7E+2 3E-7 1E-9 - -  
27 Cobalt-60m2 W, see 55Co 1E+6 4E+6 2E-3 6E-6 - -  
 St wall  
 (1E+6) - - - 2E-2 2E-1  
 Y, see 55Co - 3E+6 1E-3 4E-6 - -  
27 Cobalt-60 W, see 55Co 5E+2 2E+2 7E-8 2E-10 3E-6 3E-5  
 Y, see 55Co 2E+2 3E+1 1E-8 5E-11 - -  
27 Cobalt-612 W, see 55Co 2E+4 6E+4 3E-5 9E-8 3E-4 3E-3  
 Y, see 55Co 2E+4 6E+4 2E-5 8E-8 - -  
27 Cobalt-62m2 W, see 55Co 4E+4 2E+5 7E-5 2E-7 - -  
 St wall  
 (5E+4) - - - 7E-4 7E-3  
 Y, see 55Co - 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 56Ni 2E+3 5E+3 2E-6 7E-9 2E-5 2E-4  
 W, see 56Ni - 3E+3 1E-6 4E-9 - -  
 Vapor - 6E+3 3E-6 9E-9 - -  
28 Nickel-59 D, see 56Ni 2E+4 4E+3 2E-6 5E-9 3E-4 3E-3  
 W, see 56Ni - 7E+3 3E-6 1E-8 - -  
 Vapor - 2E+3 8E-7 3E-9 - -  
28 Nickel-63 D, see 56Ni 9E+3 2E+3 7E-7 2E-9 1E-4 1E-3  
 W, see 56Ni - 3E+3 1E-6 4E-9 - -  
 Vapor - 8E+2 3E-7 1E-9 - -

28 Nickel-65 D, see 56Ni 8E+3 2E+4 1E-5 3E-8 1E-4 1E-3  
 W, see 56Ni - 3E+4 1E-5 4E-8 - -  
 Vapor - 2E+4 7E-6 2E-8 - -  
28 Nickel-66 D, see 56Ni 4E+2 2E+3 7E-7 2E-9 - -  
 LLI wall  
 (5E+2) - - - 6E-6 6E-5  
 W, see 56Ni - 6E+2 3E-7 9E-10 - -  
 Vapor - 3E+3 1E-6 4E-9 - -  
29 Copper-602 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 60Cu 1E+4 3E+4 1E-5 4E-8 2E-4 2E-3  
 W, see 60Cu - 4E+4 2E-5 6E-8 - -  
 Y, see 60Cu - 4E+4 1E-5 5E-8 - -

Table I Table II Table III  
 Effluent Releases to  
 Occupational Values Concentrations Sewers

Col. 1 Col. 2 Col. 3 Col. 1 Col. 2  
 Oral Monthly  
 Ingestion Inhalation Average  
Atomic ALI ALI DAC Air Water Concentration  
No. Radionuclide Class (Ci) (Ci) (Ci/ml) (Ci/ml) (Ci/ml) (Ci/ml)

29 Copper-64 D, see 60Cu 1E+4 3E+4 1E-5 4E-8 2E-4 2E-3  
 W, see 60Cu - 2E+4 1E-5 3E-8 - -  
 Y, see 60Cu - 2E+4 9E-6 3E-8 - -  
29 Copper-67 D, see 60Cu 5E+3 8E+3 3E-6 1E-8 6E-5 6E-4  
 W, see 60Cu - 5E+3 2E-6 7E-9 - -  
 Y, see 60Cu - 5E+3 2E-6 6E-9 - -  
30 Zinc-62 Y, all compounds 1E+3 3E+3 1E-6 4E-9 2E-5 2E-4  
30 Zinc-632 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-692 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-652 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 65Ga 1E+3 4E+3 1E-6 5E-9 1E-5 1E-4  
 W, see 65Ga - 3E+3 1E-6 4E-9 - -  
31 Gallium-67 D, see 65Ga 7E+3 1E+4 6E-6 2E-8 1E-4 1E-3  
 W, see 65Ga - 1E+4 4E-6 1E-8 - -  
31 Gallium-682 D, see 65Ga 2E+4 4E+4 2E-5 6E-8 2E-4 2E-3  
 W, see 65Ga - 5E+4 2E-5 7E-8 - -  
31 Gallium-702 D, see 65Ga 5E+4 2E+5 7E-5 2E-7 - -  
 St wall  
 (7E+4) - - - 1E-3 1E-2  
 W, see 65Ga - 2E+5 8E-5 3E-7 - -  
31 Gallium-72 D, see 65Ga 1E+3 4E+3 1E-6 5E-9 2E-5 2E-4  
 W, see 65Ga - 3E+3 1E-6 4E-9 - -  
31 Gallium-73 D, see 65Ga 5E+3 2E+4 6E-6 2E-8 7E-5 7E-4  
 W, see 65Ga - 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-672 D, see 66Ge 3E+4 9E+4 4E-5 1E-7 - -  
 St wall  
 (4E+4) - - - 6E-4 6E-3  
 W, see 66Ge - 1E+5 4E-5 1E-7 - -  
32 Germanium-68 D, see 66Ge 5E+3 4E+3 2E-6 5E-9 6E-5 6E-4  
 W, see 66Ge - 1E+2 4E-8 1E-10 - -  
32 Germanium-69 D, see 66Ge 1E+4 2E+4 6E-6 2E-8 2E-4 2E-3  
 W, see 66Ge - 8E+3 3E-6 1E-8 - -  
32 Germanium-71 D, see 66Ge 5E+5 4E+5 2E-4 6E-7 7E-3 7E-2  
 W, see 66Ge - 4E+4 2E-5 6E-8 - -  
32 Germanium-752 D, see 66Ge 4E+4 8E+4 3E-5 1E-7 - -  
 St wall  
 (7E+4) - - - 9E-4 9E-3  
 W, see 66Ge - 8E+4 4E-5 1E-7 - -

32 Germanium-77 D, see 66Ge 9E+3 1E+4 4E-6 1E-8 1E-4 1E-3  
 W, see 66Ge - 6E+3 2E-6 8E-9 - -  
32 Germanium-782 D, see 66Ge 2E+4 2E+4 9E-6 3E-8 - -  
 St wall  
 (2E+4) - - - 3E-4 3E-3  
 W, see 66Ge - 2E+4 9E-6 3E-8 - -  
33 Arsenic-692 W, all compounds 3E+4 1E+5 5E-5 2E-7 - -  
 St wall  
 (4E+4) - - - 6E-4 6E-3  
33 Arsenic-702 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-78² W, all compounds 8E+3 2E+4 9E-6 3E-8 1E-4 1E-3  
34 Selenium-702 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 - -

Table I Table II Table III  
 Effluent Releases to  
 Occupational Values Concentrations Sewers

Col. 1 Col. 2 Col. 3 Col. 1 Col. 2  
 Oral Monthly  
 Ingestion Inhalation Average  
Atomic ALI ALI DAC Air Water Concentration  
No. Radionuclide Class (Ci) (Ci) (Ci/ml) (Ci/ml) (Ci/ml) (Ci/ml)

34 Selenium-73m2 D, see 70Se 6E+4 2E+5 6E-5 2E-7 4E-4 4E-3  
 W, see 70Se 3E+4 1E+5 6E-5 2E-7 - -  
34 Selenium-73 D, see 70Se 3E+3 1E+4 5E-6 2E-8 4E-5 4E-4  
 W, see 70Se - 2E+4 7E-6 2E-8 - -  
34 Selenium-75 D, see 70Se 5E+2 7E+2 3E-7 1E-9 7E-6 7E-5  
 W, see 70Se - 6E+2 3E-7 8E-10 - -  
34 Selenium-79 D, see 70Se 6E+2 8E+2 3E-7 1E-9 8E-6 8E-5  
 W, see 70Se - 6E+2 2E-7 8E-10 - -  
34 Selenium-81m2 D, see 70Se 4E+4 7E+4 3E-5 9E-8 3E-4 3E-3  
 W, see 70Se 2E+4 7E+4 3E-5 1E-7 - -  
34 Selenium-812 D, see 70Se 6E+4 2E+5 9E-5 3E-7 - -  
 St wall  
 (8E+4) - - - 1E-3 1E-2  
 W, see 70Se - 2E+5 1E-4 3E-7 - -  
34 Selenium-832 D, see 70Se 4E+4 1E+5 5E-5 2E-7 4E-4 4E-3  
 W, see 70Se 3E+4 1E+5 5E-5 2E-7 - -  
35 Bromine-74m2 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-742 D, see 74mBr 2E+4 7E+4 3E-5 1E-7 - -  
 St wall  
 (4E+4) - - - 5E-4 5E-3  
 W, see 74mBr - 8E+4 4E-5 1E-7 - -  
35 Bromine-752 D, see 74mBr 3E+4 5E+4 2E-5 7E-8 - -  
 St wall  
 (4E+4) - - - 5E-4 5E-3  
 W, see 74mBr - 5E+4 2E-5 7E-8 - -  
35 Bromine-76 D, see 74mBr 4E+3 5E+3 2E-6 7E-9 5E-5 5E-4  
 W, see 74mBr - 4E+3 2E-6 6E-9 - -  
35 Bromine-77 D, see 74mBr 2E+4 2E+4 1E-5 3E-8 2E-4 2E-3  
 W, see 74mBr - 2E+4 8E-6 3E-8 - -  
35 Bromine-80m D, see 74mBr 2E+4 2E+4 7E-6 2E-8 3E-4 3E-3  
 W, see 74mBr - 1E+4 6E-6 2E-8 - -  
35 Bromine-802 D, see 74mBr 5E+4 2E+5 8E-5 3E-7 - -  
 St wall  
 (9E+4) - - - 1E-3 1E-2  
 W, see 74mBr - 2E+5 9E-5 3E-7 - -

35 Bromine-82 D, see 74mBr 3E+3 4E+3 2E-6 6E-9 4E-5 4E-4  
 W, see 74mBr - 4E+3 2E-6 5E-9 - -  
35 Bromine-83 D, see 74mBr 5E+4 6E+4 3E-5 9E-8 - -  
 St wall  
 (7E+4) - - - 9E-4 9E-3  
 W, see 74mBr - 6E+4 3E-5 9E-8 - -  
35 Bromine-842 D, see 74mBr 2E+4 6E+4 2E-5 8E-8 - -  
 St wall  
 (3E+4) - - - 4E-4 4E-3  
 W, see 74mBr - 6E+4 3E-5 9E-8 - -  
36 Krypton-742 Submersion1 - - 3E-6 1E-8 - -  
36 Krypton-76 Submersion1 - - 9E-6 4E-8 - -  
36 Krypton-772 Submersion1 - - 4E-6 2E-8 - -  
36 Krypton-79 Submersion1 - - 2E-5 7E-8 - -  
36 Krypton-81 Submersion1 - - 7E-4 3E-6 - -  
36 Krypton-83m2 Submersion1 - - 1E-2 5E-5 - -  
36 Krypton-85m Submersion1 - - 2E-5 1E-7 - -  
36 Krypton-85 Submersion1 - - 1E-4 7E-7 - -  
36 Krypton-872 Submersion1 - - 5E-6 2E-8 - -  
36 Krypton-88 Submersion1 - - 2E-6 9E-9 - -  
37 Rubidium-792 D, all compounds 4E+4 1E+5 5E-5 2E-7 - -  
 St wall  
 (6E+4) - - - 8E-4 8E-3  
37 Rubidium-81m2 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-882 D, all compounds 2E+4 6E+4 3E-5 9E-8 - -  
 St wall  
 (3E+4) - - - 4E-4 4E-3

Table I Table II Table III  
 Effluent Releases to  
 Occupational Values Concentrations Sewers

Col. 1 Col. 2 Col. 3 Col. 1 Col. 2  
 Oral Monthly  
 Ingestion Inhalation Average  
Atomic ALI ALI DAC Air Water Concentration  
No. Radionuclide Class (Ci) (Ci) (Ci/ml) (Ci/ml) (Ci/ml) (Ci/ml)

37 Rubidium-892 D, all compounds 4E+4 1E+5 6E-5 2E-7 - -  
 St wall  
 (6E+4) - - - 9E-4 9E-3  
38 Strontium-802 D, all soluble compounds  
 except SrTiO 4E+3 1E+4 5E-6 2E-8 6E-5 6E-4  
 Y, all insoluble com-  
 pounds and SrTi0 - 1E+4 5E-6 2E-8 - -  
38 Strontium-812 D, see 80Sr 3E+4 8E+4 3E-5 1E-7 3E-4 3E-3  
 Y, see 80Sr 2E+4 8E+4 3E-5 1E-7 - -  
38 Strontium-82 D, see 80Sr 3E+2 4E+2 2E-7 6E-10 - -  
 LLI wall  
 (2E+2) - - - 3E-6 3E-5  
 Y, see 80Sr 2E+2 9E+1 4E-8 1E-10 - -  
38 Strontium-83 D, see 80Sr 3E+3 7E+3 3E-6 1E-8 3E-5 3E-4  
 Y, see 80Sr 2E+3 4E+3 1E-6 5E-9 - -  
38 Strontium-85m2 D, see 80Sr 2E+5 6E+5 3E-4 9E-7 3E-3 3E-2  
 Y, see 80Sr - 8E+5 4E-4 1E-6 - -  
38 Strontium-85 D, see 80Sr 3E+3 3E+3 1E-6 4E-9 4E-5 4E-4  
 Y, see 80Sr - 2E+3 6E-7 2E-9 - -  
38 Strontium-87m D, see 80Sr 5E+4 1E+5 5E-5 2E-7 6E-4 6E-3  
 Y, see 80Sr 4E+4 2E+5 6E-5 2E-7 - -  
38 Strontium-89 D, see 80Sr 6E+2 8E+2 4E-7 1E-9 - -  
 LLI wall  
 (6E+2) - - - 8E-6 8E-5  
 Y, see 80Sr 5E+2 1E+2 6E-8 2E-10 - -  
38 Strontium-90 D, see 80Sr 3E+1 2E+1 8E-9 - - -  
 Bone surf Bone surf  
 (4E+1) (2E+1) - 3E-11 5E-7 5E-6  
 Y, see 80Sr - 4E+0 2E-9 6E-12 - -  
38 Strontium-91 D, see 80Sr 2E+3 6E+3 2E-6 8E-9 2E-5 2E-4  
 Y, see 80Sr - 4E+3 1E-6 5E-9 - -  
38 Strontium-92 D, see 80Sr 3E+3 9E+3 4E-6 1E-8 4E-5 4E-4  
 Y, see 80Sr - 7E+3 3E-6 9E-9 - -  
39 Yttrium-86m2 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 86mY 1E+3 3E+3 1E-6 5E-9 2E-5 2E-4  
 Y, see 86mY - 3E+3 1E-6 5E-9 - -

39 Yttrium-87 W, see 86mY 2E+3 3E+3 1E-6 5E-9 3E-5 3E-4  
 Y, see 86mY - 3E+3 1E-6 5E-9 - -  
39 Yttrium-88 W, see 86mY 1E+3 3E+2 1E-7 3E-10 1E-5 1E-4  
 Y, see 86mY - 2E+2 1E-7 3E-10 - -  
39 Yttrium-90m W, see 86mY 8E+3 1E+4 5E-6 2E-8 1E-4 1E-3  
 Y, see 86mY - 1E+4 5E-6 2E-8 - -  
39 Yttrium-90 W, see 86mY 4E+2 7E+2 3E-7 9E-10 - -  
 LLI wall  
 (5E+2) - - - 7E-6 7E-5  
 Y, see 86mY - 6E+2 3E-7 9E-10 - -  
39 Yttrium-91m2 W, see 86mY 1E+5 2E+5 1E-4 3E-7 2E-3 2E-2  
 Y, see 86mY - 2E+5 7E-5 2E-7 - -  
39 Yttrium-91 W, see 86mY 5E+2 2E+2 7E-8 2E-10 - -  
 LLI wall  
 (6E+2) - - - 8E-6 8E-5  
 Y, see 86mY - 1E+2 5E-8 2E-10 - -  
39 Yttrium-92 W, see 86mY 3E+3 9E+3 4E-6 1E-8 4E-5 4E-4  
 Y, see 86mY - 8E+3 3E-6 1E-8 - -  
39 Yttrium-93 W, see 86mY 1E+3 3E+3 1E-6 4E-9 2E-5 2E-4  
 Y, see 86mY - 2E+3 1E-6 3E-9 - -  
39 Yttrium-942 W, see 86mY 2E+4 8E+4 3E-5 1E-7 - -  
 St wall  
 (3E+4) - - - 4E-4 4E-3  
 Y, see 86mY - 8E+4 3E-5 1E-7 - -  
39 Yttrium-952 W, see 86mY 4E+4 2E+5 6E-5 2E-7 - -  
 St wall  
 (5E+4) - - - 7E-4 7E-3  
 Y, see 86mY - 1E+5 6E-5 2E-7 - -

40 Zirconium-86 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 86Zr 4E+3 2E+2 9E-8 3E-10 5E-5 5E-4  
 W, see 86Zr - 5E+2 2E-7 7E-10 - -  
 Y, see 86Zr - 3E+2 1E-7 4E-10 - -  
40 Zirconium-89 D, see 86Zr 2E+3 4E+3 1E-6 5E-9 2E-5 2E-4  
 W, see 86Zr - 2E+3 1E-6 3E-9 - -  
 Y, see 86Zr - 2E+3 1E-6 3E-9 - -

Table I Table II Table III  
 Effluent Releases to  
 Occupational Values Concentrations Sewers

Col. 1 Col. 2 Col. 3 Col. 1 Col. 2  
 Oral Monthly  
 Ingestion Inhalation Average  
Atomic ALI ALI DAC Air Water Concentration  
No. Radionuclide Class (Ci) (Ci) (Ci/ml) (Ci/ml) (Ci/ml) (Ci/ml)

40 Zirconium-93 D, see 86Zr 1E+3 6E+0 3E-9 - - -  
 Bone surf Bone surf  
 (3E+3) (2E+1) - 2E-11 4E-5 4E-4  
 W, see 86Zr - 2E+1 1E-8 - - -  
 Bone surf  
 - (6E+1) - 9E-11 - -  
 Y, see 86Zr - 6E+1 2E-8 - - -  
 Bone surf  
 - (7E+1) - 9E-11 - -  
40 Zirconium-95 D, see 86Zr 1E+3 1E+2 5E-8 - 2E-5 2E-4  
 Bone surf  
 - (3E+2) - 4E-10 - -  
 W, see 86Zr - 4E+2 2E-7 5E-10 - -  
 Y, see 86Zr - 3E+2 1E-7 4E-10 - -  
40 Zirconium-97 D, see 86Zr 6E+2 2E+3 8E-7 3E-9 9E-6 9E-5  
 W, see 86Zr - 1E+3 6E-7 2E-9 - -  
 Y, see 86Zr - 1E+3 5E-7 2E-9 - -  
41 Niobium-882 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-892 W, see 88Nb 1E+4 4E+4 2E-5 6E-8 1E-4 1E-3  
 (66 min)  
 Y, see 88Nb - 4E+4 2E-5 5E-8 - -  
41 Niobium-89 W, see 88Nb 5E+3 2E+4 8E-6 3E-8 7E-5 7E-4  
 (122 min)  
 Y, see 88Nb - 2E+4 6E-6 2E-8 - -  
41 Niobium-90 W, see 88Nb 1E+3 3E+3 1E-6 4E-9 1E-5 1E-4  
 Y, see 88Nb - 2E+3 1E-6 3E-9 - -  
41 Niobium-93m W, see 88Nb 9E+3 2E+3 8E-7 3E-9 - -  
 LLI wall  
 (1E+4) - - - 2E-4 2E-3  
 Y, see 88Nb - 2E+2 7E-8 2E-10 - -

41 Niobium-94 W, see 88Nb 9E+2 2E+2 8E-8 3E-10 1E-5 1E-4  
 Y, see 88Nb - 2E+1 6E-9 2E-11 - -  
41 Niobium-95m W, see 88Nb 2E+3 3E+3 1E-6 4E-9 - -  
 LLI wall  
 (2E+3) - - - 3E-5 3E-4  
 Y, see 88Nb - 2E+3 9E-7 3E-9 - -  
41 Niobium-95 W, see 88Nb 2E+3 1E+3 5E-7 2E-9 3E-5 3E-4  
 Y, see 88Nb - 1E+3 5E-7 2E-9 - -  
41 Niobium-96 W, see 88Nb 1E+3 3E+3 1E-6 4E-9 2E-5 2E-4  
 Y, see 88Nb - 2E+3 1E-6 3E-9 - -  
41 Niobium-972 W, see 88Nb 2E+4 8E+4 3E-5 1E-7 3E-4 3E-3  
 Y, see 88Nb - 7E+4 3E-5 1E-7 - -  
41 Niobium-982 W, see 88Nb 1E+4 5E+4 2E-5 8E-8 2E-4 2E-3  
 Y, see 88Nb - 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 90Mo 9E+3 2E+4 7E-6 2E-8 6E-5 6E-4  
 Y, see 90Mo 4E+3 1E+4 6E-6 2E-8 - -  
42 Molybdenum-93 D, see 90Mo 4E+3 5E+3 2E-6 8E-9 5E-5 5E-4  
 Y, see 90Mo 2E+4 2E+2 8E-8 2E-10 - -  
42 Molybdenum-99 D, see 90Mo 2E+3 3E+3 1E-6 4E-9 - -  
 LLI wall  
 (1E+3) - - - 2E-5 2E-4  
 Y, see 90Mo 1E+3 1E+3 6E-7 2E-9 - -  
42 Molybdenum-1012 D, see 90Mo 4E+4 1E+5 6E-5 2E-7 - -  
 St wall  
 (5E+4) - - - 7E-4 7E-3  
 Y, see 90Mo - 1E+5 6E-5 2E-7 - -  
43 Technetium-93m2 D, all compounds except  
 those given for W 7E+4 2E+5 6E-5 2E-7 1E-3 1E-2  
 W, oxides, hydroxides,  
 halides, and nitrates - 3E+5 1E-4 4E-7 - -

43 Technetium-93 D, see 93mTc 3E+4 7E+4 3E-5 1E-7 4E-4 4E-3  
 W, see 93mTc - 1E+5 4E-5 1E-7 - -  
43 Technetium-94m2 D, see 93mTc 2E+4 4E+4 2E-5 6E-8 3E-4 3E-3  
 W, see 93mTc - 6E+4 2E-5 8E-8 - -  
43 Technetium-94 D, see 93mTc 9E+3 2E+4 8E-6 3E-8 1E-4 1E-3  
 W, see 93mTc - 2E+4 1E-5 3E-8 - -  
43 Technetium-95m D, see 93mTc 4E+3 5E+3 2E-6 8E-9 5E-5 5E-4  
 W, see 93mTc - 2E+3 8E-7 3E-9 - -  
43 Technetium-95 D, see 93mTc 1E+4 2E+4 9E-6 3E-8 1E-4 1E-3  
 W, see 93mTc - 2E+4 8E-6 3E-8 - -  
43 Technetium-96m2 D, see 93mTc 2E+5 3E+5 1E-4 4E-7 2E-3 2E-2  
 W, see 93mTc - 2E+5 1E-4 3E-7 - -  
43 Technetium-96 D, see 93mTc 2E+3 3E+3 1E-6 5E-9 3E-5 3E-4  
 W, see 93mTc - 2E+3 9E-7 3E-9 - -

Table I Table II Table III  
 Effluent Releases to  
 Occupational Values Concentrations Sewers

Col. 1 Col. 2 Col. 3 Col. 1 Col. 2  
 Oral Monthly  
 Ingestion Inhalation Average  
Atomic ALI ALI DAC Air Water Concentration  
No. Radionuclide Class (Ci) (Ci) (Ci/ml) (Ci/ml) (Ci/ml) (Ci/ml)

43 Technetium-97m D, see 93mTc 5E+3 7E+3 3E-6 - 6E-5 6E-4  
 St wall  
 - (7E+3) - 1E-8 - -  
 W, see 93mTc - 1E+3 5E-7 2E-9 - -  
43 Technetium-97 D, see 93mTc 4E+4 5E+4 2E-5 7E-8 5E-4 5E-3  
 W, see 93mTc - 6E+3 2E-6 8E-9 - -  
43 Technetium-98 D, see 93mTc 1E+3 2E+3 7E-7 2E-9 1E-5 1E-4  
 W, see 93mTc - 3E+2 1E-7 4E-10 - -  
43 Technetium-99m D, see 93mTc 8E+4 2E+5 6E-5 2E-7 1E-3 1E-2  
 W, see 93mTc - 2E+5 1E-4 3E-7 - -  
43 Technetium-99 D, see 93mTc 4E+3 5E+3 2E-6 - 6E-5 6E-4  
 St wall  
 - (6E+3) - 8E-9 - -  
 W, see 93mTc - 7E+2 3E-7 9E-10 - -  
43 Technetium-1012 D, see 93mTc 9E+4 3E+5 1E-4 5E-7 - -  
 St wall  
 (1E+5) - - - 2E-3 2E-2  
 W, see 93mTc - 4E+5 2E-4 5E-7 - -  
43 Technetium-1042 D, see 93mTc 2E+4 7E+4 3E-5 1E-7 - -  
 St wall  
 (3E+4) - - - 4E-4 4E-3  
 W, see 93mTc - 9E+4 4E-5 1E-7 - -  
44 Ruthenium-942 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 - -  
 Y, oxides and hydroxides - 6E+4 2E-5 8E-8 - -  
44 Ruthenium-97 D, see 94Ru 8E+3 2E+4 8E-6 3E-8 1E-4 1E-3  
 W, see 94Ru - 1E+4 5E-6 2E-8 - -  
 Y, see 94Ru - 1E+4 5E-6 2E-8 - -  
44 Ruthenium-103 D, see 94Ru 2E+3 2E+3 7E-7 2E-9 3E-5 3E-4  
 W, see 94Ru - 1E+3 4E-7 1E-9 - -  
 Y, see 94Ru - 6E+2 3E-7 9E-10 - -  
44 Ruthenium-105 D, see 94Ru 5E+3 1E+4 6E-6 2E-8 7E-5 7E-4  
 W, see 94Ru - 1E+4 6E-6 2E-8 - -  
 Y, see 94Ru - 1E+4 5E-6 2E-8 - -  
44 Ruthenium-106 D, see 94Ru 2E+2 9E+1 4E-8 1E-10 - -  
 LLI wall  
 (2E+2) - - - 3E-6 3E-5  
 W, see 94Ru - 5E+1 2E-8 8E-11 - -  
 Y, see 94Ru - 1E+1 5E-9 2E-11 - -  
45 Rhodium-99m D, all compounds except  
 those given for W and Y 2E+4 6E+4 2E-5 8E-8 2E-4 2E-3  
 W, halides - 8E+4 3E-5 1E-7 - -  
 Y, oxides and hydroxides - 7E+4 3E-5 9E-8 - -  
45 Rhodium-99 D, see 99mRh 2E+3 3E+3 1E-6 4E-9 3E-5 3E-4  
 W, see 99mRh - 2E+3 9E-7 3E-9 - -  
 Y, see 99mRh - 2E+3 8E-7 3E-9 - -  
45 Rhodium-100 D, see 99mRh 2E+3 5E+3 2E-6 7E-9 2E-5 2E-4  
 W, see 99mRh - 4E+3 2E-6 6E-9 - -  
 Y, see 99mRh - 4E+3 2E-6 5E-9 - -  
45 Rhodium-101m D, see 99mRh 6E+3 1E+4 5E-6 2E-8 8E-5 8E-4  
 W, see 99mRh - 8E+3 4E-6 1E-8 - -  
 Y, see 99mRh - 8E+3 3E-6 1E-8 - -  
45 Rhodium-101 D, see 99mRh 2E+3 5E+2 2E-7 7E-10 3E-5 3E-4  
 W, see 99mRh - 8E+2 3E-7 1E-9 - -  
 Y, see 99mRh - 2E+2 6E-8 2E-10 - -  
45 Rhodium-102m D, see 99mRh 1E+3 5E+2 2E-7 7E-10 - -  
 LLI wall  
 (1E+3) - - - 2E-5 2E-4  
 W, see 99mRh - 4E+2 2E-7 5E-10 - -  
 Y, see 99mRh - 1E+2 5E-8 2E-10 - -  
45 Rhodium-102 D, see 99mRh 6E+2 9E+1 4E-8 1E-10 8E-6 8E-5  
 W, see 99mRh - 2E+2 7E-8 2E-10 - -  
 Y, see 99mRh - 6E+1 2E-8 8E-11 - -  
45 Rhodium-103m2 D, see 99mRh 4E+5 1E+6 5E-4 2E-6 6E-3 6E-2  
 W, see 99mRh - 1E+6 5E-4 2E-6 - -  
 Y, see 99mRh - 1E+6 5E-4 2E-6 - -  
45 Rhodium-105 D, see 99mRh 4E+3 1E+4 5E-6 2E-8 - -  
 LLI wall  
 (4E+3) - - - 5E-5 5E-4  
 W, see 99mRh - 6E+3 3E-6 9E-9 - -  
 Y, see 99mRh - 6E+3 2E-6 8E-9 - -  
45 Rhodium-106m D, see 99mRh 8E+3 3E+4 1E-5 4E-8 1E-4 1E-3  
 W, see 99mRh - 4E+4 2E-5 5E-8 - -  
 Y, see 99mRh - 4E+4 1E-5 5E-8 - -  
45 Rhodium-1072 D, see 99mRh 7E+4 2E+5 1E-4 3E-7 - -  
 St wall  
 (9E+4) - - - 1E-3 1E-2  
 W, see 99mRh - 3E+5 1E-4 4E-7 - -  
 Y, see 99mRh - 3E+5 1E-4 3E-7 - -

Table I Table II Table III  
 Effluent Releases to  
 Occupational Values Concentrations Sewers

Col. 1 Col. 2 Col. 3 Col. 1 Col. 2  
 Oral Monthly  
 Ingestion Inhalation Average  
Atomic ALI ALI DAC Air Water Concentration  
No. Radionuclide Class (Ci) (Ci) (Ci/ml) (Ci/ml) (Ci/ml) (Ci/ml)

46 Palladium-100 D, all compounds except  
 those given for W and Y 1E+3 1E+3 6E-7 2E-9 2E-5 2E-4  
 W, nitrates - 1E+3 5E-7 2E-9 - -  
 Y, oxides and hydroxides - 1E+3 6E-7 2E-9 - -  
46 Palladium-101 D, see 100Pd 1E+4 3E+4 1E-5 5E-8 2E-4 2E-3  
 W, see 100Pd - 3E+4 1E-5 5E-8 - -  
 Y, see 100Pd - 3E+4 1E-5 4E-8 - -  
46 Palladium-103 D, see 100Pd 6E+3 6E+3 3E-6 9E-9 - -  
 LLI wall   
 (7E+3) - - - 1E-4 1E-3  
 W, see 100Pd - 4E+3 2E-6 6E-9 - -  
 Y, see 100Pd - 4E+3 1E-6 5E-9 - -  
46 Palladium-107 D, see 100Pd 3E+4 2E+4 9E-6 - - -  
 LLI wall Kidneys  
 (4E+4) (2E+4) - 3E-8 5E-4 5E-3  
 W, see 100Pd - 7E+3 3E-6 1E-8 - -  
 Y, see 100Pd - 4E+2 2E-7 6E-10 - -  
46 Palladium-109 D, see 100Pd 2E+3 6E+3 3E-6 9E-9 3E-5 3E-4  
 W, see 100Pd - 5E+3 2E-6 8E-9 - -  
 Y, see 100Pd - 5E+3 2E-6 6E-9 - -  
47 Silver-1022 D, all compounds except  
 those given for W and Y 5E+4 2E+5 8E-5 2E-7 - -  
 St wall  
 (6E+4) - - - 9E-4 9E-3  
 W, nitrates and sulfides - 2E+5 9E-5 3E-7 - -  
 Y, oxides and hydroxides - 2E+5 8E-5 3E-7 - -  
47 Silver-1032 D, see 102Ag 4E+4 1E+5 4E-5 1E-7 5E-4 5E-3  
 W, see 102Ag - 1E+5 5E-5 2E-7 - -  
 Y, see 102Ag - 1E+5 5E-5 2E-7 - -  
47 Silver-104m2 D, see 102Ag 3E+4 9E+4 4E-5 1E-7 4E-4 4E-3  
 W, see 102Ag - 1E+5 5E-5 2E-7 - -  
 Y, see 102Ag - 1E+5 5E-5 2E-7 - -  
47 Silver-1042 D, see 102Ag 2E+4 7E+4 3E-5 1E-7 3E-4 3E-3  
 W, see 102Ag - 1E+5 6E-5 2E-7 - -  
 Y, see 102Ag - 1E+5 6E-5 2E-7 - -  
47 Silver-105 D, see 102Ag 3E+3 1E+3 4E-7 1E-9 4E-5 4E-4  
 W, see 102Ag - 2E+3 7E-7 2E-9 - -  
 Y, see 102Ag - 2E+3 7E-7 2E-9 - -  
47 Silver-106m D, see 102Ag 8E+2 7E+2 3E-7 1E-9 1E-5 1E-4  
 W, see 102Ag - 9E+2 4E-7 1E-9 - -  
 Y, see 102Ag - 9E+2 4E-7 1E-9 - -  
47 Silver-1062 D, see 102Ag 6E+4 2E+5 8E-5 3E-7 - -  
 St. wall  
 (6E+4) - - - 9E-4 9E-3  
 W, see 102Ag - 2E+5 9E-5 3E-7 - -  
 Y, see 102Ag - 2E+5 8E-5 3E-7 - -  
47 Silver-108m D, see 102Ag 6E+2 2E+2 8E-8 3E-10 9E-6 9E-5  
 W, see 102Ag - 3E+2 1E-7 4E-10 - -  
 Y, see 102Ag - 2E+1 1E-8 3E-11 - -  
47 Silver-110m D, see 102Ag 5E+2 1E+2 5E-8 2E-10 6E-6 6E-5  
 W, see 102Ag - 2E+2 8E-8 3E-10 - -  
 Y, see 102Ag - 9E+1 4E-8 1E-10 - -  
47 Silver-111 D, see 102Ag 9E+2 2E+3 6E-7 - - -  
 LLI wall Liver  
 (1E+3) (2E+3) - 2E-9 2E-5 2E-4  
 W, see 102Ag - 9E+2 4E-7 1E-9 - -  
 Y, see 102Ag - 9E+2 4E-7 1E-9 - -  
47 Silver-112 D, see 102Ag 3E+3 8E+3 3E-6 1E-8 4E-5 4E-4  
 W, see 102Ag - 1E+4 4E-6 1E-8 - -  
 Y, see 102Ag - 9E+3 4E-6 1E-8 - -  
47 Silver-1152 D, see 102Ag 3E+4 9E+4 4E-5 1E-7 - -  
 St wall  
 (3E+4) - - - 4E-4 4E-3  
 W, see 102Ag - 9E+4 4E-5 1E-7 - -  
 Y, see 102Ag - 8E+4 3E-5 1E-7 - -  
48 Cadmium-1042 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 - -  
 Y, oxides and hydroxides - 1E+5 5E-5 2E-7 - -  
48 Cadmium-107 D, see 104Cd 2E+4 5E+4 2E-5 8E-8 3E-4 3E-3  
 W, see 104Cd - 6E+4 2E-5 8E-8 - -  
 Y, see 104Cd - 5E+4 2E-5 7E-8 - -  
48 Cadmium-109 D, see 104Cd 3E+2 4E+1 1E-8 - - -  
 Kidneys Kidneys  
 (4E+2) (5E+1) - 7E-11 6E-6 6E-5  
 W, see 104Cd - 1E+2 5E-8 - - -  
 Kidneys  
 - (1E+2) - 2E-10 - -  
 Y, see 104Cd - 1E+2 5E-8 2E-10 - -

Table I Table II Table III  
 Effluent Releases to  
 Occupational Values Concentrations Sewers

Col. 1 Col. 2 Col. 3 Col. 1 Col. 2  
 Oral Monthly  
 Ingestion Inhalation Average  
Atomic ALI ALI DAC Air Water Concentration  
No. Radionuclide Class (Ci) (Ci) (Ci/ml) (Ci/ml) (Ci/ml) (Ci/ml)

48 Cadmium-113m D, see 104Cd 2E+1 2E+0 1E-9 - - -  
 Kidneys Kidneys  
 (4E+1) (4E+0) - 5E-12 5E-7 5E-6  
 W, see 104Cd - 8E+0 4E-9 - - -  
 Kidneys  
 - (1E+1) - 2E-11 - -  
 Y, see 104Cd - 1E+1 5E-9 2E-11 - -  
48 Cadmium-113 D, see 104Cd 2E+1 2E+0 9E-10 - - -  
 Kidneys Kidneys  
 (3E+1) (3E+0) - 5E-12 4E-7 4E-6  
 W, see 104Cd - 8E+0 3E-9 - - -  
 Kidneys  
 - (1E+1) - 2E-11 - -  
 Y, see 104Cd - 1E+1 6E-9 2E-11 - -  
48 Cadmium-115m D, see 104Cd 3E+2 5E+1 2E-8 - 4E-6 4E-5  
 Kidneys  
 - (8E+1) - 1E-10 - -  
 W, see 104Cd - 1E+2 5E-8 2E-10 - -  
 Y, see 104Cd - 1E+2 6E-8 2E-10 - -  
48 Cadmium-115 D, see 104Cd 9E+2 1E+3 6E-7 2E-9 - -  
 LLI wall  
 (1E+3) - - - 1E-5 1E-4  
 W, see 104Cd - 1E+3 5E-7 2E-9 - -  
 Y, see 104Cd - 1E+3 6E-7 2E-9 - -  
48 Cadmium-117m D, see 104Cd 5E+3 1E+4 5E-6 2E-8 6E-5 6E-4  
 W, see 104Cd - 2E+4 7E-6 2E-8 - -  
 Y, see 104Cd - 1E+4 6E-6 2E-8 - -  
48 Cadmium-117 D, see 104Cd 5E+3 1E+4 5E-6 2E-8 6E-5 6E-4  
 W, see 104Cd - 2E+4 7E-6 2E-8 - -  
 Y, see 104Cd - 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-1102 D, see 109In 2E+4 4E+4 2E-5 6E-8 2E-4 2E-3  
 (69.1 min) W, see 109In - 6E+4 2E-5 8E-8 - -  
49 Indium-110 D, see 109In 5E+3 2E+4 7E-6 2E-8 7E-5 7E-4  
 (4.9 h) W, see 109In - 2E+4 8E-6 3E-8 - -  
49 Indium-111 D, see 109In 4E+3 6E+3 3E-6 9E-9 6E-5 6E-4  
 W, see 109In - 6E+3 3E-6 9E-9 - -  
49 Indium-1122 D, see 109In 2E+5 6E+5 3E-4 9E-7 2E-3 2E-2  
 W, see 109In - 7E+5 3E-4 1E-6 - -  
49 Indium-113m2 D, see 109In 5E+4 1E+5 6E-5 2E-7 7E-4 7E-3  
 W, see 109In - 2E+5 8E-5 3E-7 - -  
49 Indium-114m D, see 109In 3E+2 6E+1 3E-8 9E-11 - -  
 LLI wall  
 (4E+2) - - - 5E-6 5E-5  
 W, see 109In - 1E+2 4E-8 1E-10 - -  
49 Indium-115m D, see 109In 1E+4 4E+4 2E-5 6E-8 2E-4 2E-3  
 W, see 109In - 5E+4 2E-5 7E-8 - -  
49 Indium-115 D, see 109In 4E+1 1E+0 6E-10 2E-12 5E-7 5E-6  
 W, see 109In - 5E+0 2E-9 8E-12 - -  
49 Indium-116m2 D, see 109In 2E+4 8E+4 3E-5 1E-7 3E-4 3E-3  
 W, see 109In - 1E+5 5E-5 2E-7 - -  
49 Indium-117m2 D, see 109In 1E+4 3E+4 1E-5 5E-8 2E-4 2E-3  
 W, see 109In - 4E+4 2E-5 6E-8 - -  
49 Indium-1172 D, see 109In 6E+4 2E+5 7E-5 2E-7 8E-4 8E-3  
 W, see 109In - 2E+5 9E-5 3E-7 - -  
49 Indium-119m2 D, see 109In 4E+4 1E+5 5E-5 2E-7 - -  
 St wall  
 (5E+4) - - - 7E-4 7E-3  
 W, see 109In - 1E+5 6E-5 2E-7 - -  
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-1112 D, see 110Sn 7E+4 2E+5 9E-5 3E-7 1E-3 1E-2  
 W, see 110Sn - 3E+5 1E-4 4E-7 - -  
50 Tin-113 D, see 110Sn 2E+3 1E+3 5E-7 2E-9 - -  
 LLI wall  
 (2E+3) - - - 3E-5 3E-4  
 W, see 110Sn - 5E+2 2E-7 8E-10 - -  
50 Tin-117m D, see 110Sn 2E+3 1E+3 5E-7 - - -  
 LLI wall Bone surf  
 (2E+3) (2E+3) - 3E-9 3E-5 3E-4  
 W, see 110Sn - 1E+3 6E-7 2E-9 - -  
50 Tin-119m D, see 110Sn 3E+3 2E+3 1E-6 3E-9 - -  
 LLI wall  
 (4E+3) - - - 6E-5 6E-4  
 W, see 110Sn - 1E+3 4E-7 1E-9 - -

Table I Table II Table III  
 Effluent Releases to  
 Occupational Values Concentrations Sewers

Col. 1 Col. 2 Col. 3 Col. 1 Col. 2  
 Oral Monthly  
 Ingestion Inhalation Average  
Atomic ALI ALI DAC Air Water Concentration  
No. Radionuclide Class (Ci) (Ci) (Ci/ml) (Ci/ml) (Ci/ml) (Ci/ml)

50 Tin-121m D, see 110Sn 3E+3 9E+2 4E-7 1E-9 - -  
 LLI wall  
 (4E+3) - - - 5E-5 5E-4  
 W, see 110Sn - 5E+2 2E-7 8E-10 - -  
50 Tin-121 D, see 110Sn 6E+3 2E+4 6E-6 2E-8 - -  
 LLI wall  
 (6E+3) - - - 8E-5 8E-4  
 W, see 110Sn - 1E+4 5E-6 2E-8 - -  
50 Tin-123m2 D, see 110Sn 5E+4 1E+5 5E-5 2E-7 7E-4 7E-3  
 W, see 110Sn - 1E+5 6E-5 2E-7 - -  
50 Tin-123 D, see 110Sn 5E+2 6E+2 3E-7 9E-10 - -  
 LLI wall  
 (6E+2) - - - 9E-6 9E-5  
 W, see 110Sn - 2E+2 7E-8 2E-10 - -  
50 Tin-125 D, see 110Sn 4E+2 9E+2 4E-7 1E-9 - -  
 LLI wall  
 (5E+2) - - - 6E-6 6E-5  
 W, see 110Sn - 4E+2 1E-7 5E-10 - -  
50 Tin-126 D, see 110Sn 3E+2 6E+1 2E-8 8E-11 4E-6 4E-5  
 W, see 110Sn - 7E+1 3E-8 9E-11 - -  
50 Tin-127 D, see 110Sn 7E+3 2E+4 8E-6 3E-8 9E-5 9E-4  
 W, see 110Sn - 2E+4 8E-6 3E-8 - -  
50 Tin-1282 D, see 110Sn 9E+3 3E+4 1E-5 4E-8 1E-4 1E-3  
 W, see 110Sn - 4E+4 1E-5 5E-8 - -  
51 Antimony-1152 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-116m2 D, see 115Sb 2E+4 7E+4 3E-5 1E-7 3E-4 3E-3  
 W, see 115Sb - 1E+5 6E-5 2E-7 - -  
51 Antimony-1162 D, see 115Sb 7E+4 3E+5 1E-4 4E-7 - -  
 St wall  
 (9E+4) - - - 1E-3 1E-2  
 W, see 115Sb - 3E+5 1E-4 5E-7 - -  
51 Antimony-117 D, see 115Sb 7E+4 2E+5 9E-5 3E-7 9E-4 9E-3  
 W, see 115Sb - 3E+5 1E-4 4E-7 - -  
51 Antimony-118m D, see 115Sb 6E+3 2E+4 8E-6 3E-8 7E-5 7E-4  
 W, see 115Sb 5E+3 2E+4 9E-6 3E-8 - -  
51 Antimony-119 D, see 115Sb 2E+4 5E+4 2E-5 6E-8 2E-4 2E-3  
 W, see 115Sb 2E+4 3E+4 1E-5 4E-8 - -  
51 Antimony-1202 D, see 115Sb 1E+5 4E+5 2E-4 6E-7 - -  
 (16 min) St wall  
 (2E+5) - - - 2E-3 2E-2  
 W, see 115Sb - 5E+5 2E-4 7E-7 - -  
51 Antimony-120 D, see 115Sb 1E+3 2E+3 9E-7 3E-9 1E-5 1E-4  
 (5.76 d) W, see 115Sb 9E+2 1E+3 5E-7 2E-9 - -  
51 Antimony-122 D, see 115Sb 8E+2 2E+3 1E-6 3E-9 - -  
 LLI wall  
 (8E+2) - - - 1E-5 1E-4  
 W, see 115Sb 7E+2 1E+3 4E-7 2E-9 - -  
51 Antimony-124m2 D, see 115Sb 3E+5 8E+5 4E-4 1E-6 3E-3 3E-2  
 W, see 115Sb 2E+5 6E+5 2E-4 8E-7 - -  
51 Antimony-124 D, see 115Sb 6E+2 9E+2 4E-7 1E-9 7E-6 7E-5  
 W, see 115Sb 5E+2 2E+2 1E-7 3E-10 - -  
51 Antimony-125 D, see 115Sb 2E+3 2E+3 1E-6 3E-9 3E-5 3E-4  
 W, see 115Sb - 5E+2 2E-7 7E-10 - -  
51 Antimony-126m2 D, see 115Sb 5E+4 2E+5 8E-5 3E-7 - -  
 St wall  
 (7E+4) - - - 9E-4 9E-3  
 W, see 115Sb - 2E+5 8E-5 3E-7 - -  
51 Antimony-126 D, see 115Sb 6E+2 1E+3 5E-7 2E-9 7E-6 7E-5  
 W, see 115Sb 5E+2 5E+2 2E-7 7E-10 - -  
51 Antimony-127 D, see 115Sb 8E+2 2E+3 9E-7 3E-9 - -  
 LLI wall  
 (8E+2) - - - 1E-5 1E-4  
 W, see 115Sb 7E+2 9E+2 4E-7 1E-9 - -  
51 Antimony-1282 D, see 115Sb 8E+4 4E+5 2E-4 5E-7 - -  
 (10.4 min) St wall  
 (1E+5) - - - 1E-3 1E-2  
 W, see 115Sb - 4E+5 2E-4 6E-7 - -  
51 Antimony-128 D, see 115Sb 1E+3 4E+3 2E-6 6E-9 2E-5 2E-4  
 (9.01 h) W, see 115Sb - 3E+3 1E-6 5E-9 - -  
51 Antimony-129 D, see 115Sb 3E+3 9E+3 4E-6 1E-8 4E-5 4E-4  
 W, see 115Sb - 9E+3 4E-6 1E-8 - -  
51 Antimony-1302 D, see 115Sb 2E+4 6E+4 3E-5 9E-8 3E-4 3E-3  
 W, see 115Sb - 8E+4 3E-5 1E-7 - -

Table I Table II Table III  
 Effluent Releases to  
 Occupational Values Concentrations Sewers

Col. 1 Col. 2 Col. 3 Col. 1 Col. 2  
 Oral Monthly  
 Ingestion Inhalation Average  
Atomic ALI ALI DAC Air Water Concentration  
No. Radionuclide Class (Ci) (Ci) (Ci/ml) (Ci/ml) (Ci/ml) (Ci/ml)

51 Antimony-1312 D, see 115Sb 1E+4 2E+4 1E-5 - - -  
 Thyroid Thyroid  
 (2E+4) (4E+4) - 6E-8 2E-4 2E-3  
 W, see 115Sb - 2E+4 1E-5 - -  
 Thyroid  
 - (4E+4) - 6E-8 - -  
52 Tellurium-116 D, all compounds except  
 those given for W 8E+3 2E+4 9E-6 3E-8 1E-4 1E-3  
 W, oxides, hydroxides,  
 and nitrates - 3E+4 1E-5 4E-8 - -  
52 Tellurium-121m D, see 116Te 5E+2 2E+2 8E-8 - - -  
 Bone surf Bone surf  
 (7E+2) (4E+2) - 5E-10 1E-5 1E-4  
 W, see 116Te - 4E+2 2E-7 6E-10 - -  
52 Tellurium-121 D, see 116Te 3E+3 4E+3 2E-6 6E-9 4E-5 4E-4  
 W, see 116Te - 3E+3 1E-6 4E-9 - -  
52 Tellurium-123m D, see 116Te 6E+2 2E+2 9E-8 - - -  
 Bone surf Bone surf  
 (1E+3) (5E+2) - 8E-10 1E-5 1E-4  
 W, see 116Te - 5E+2 2E-7 8E-10 - -  
52 Tellurium-123 D, see 116Te 5E+2 2E+2 8E-8 - - -  
 Bone surf Bone surf  
 (1E+3) (5E+2) - 7E-10 2E-5 2E-4  
 W, see 116Te - 4E+2 2E-7 - - -  
 Bone surf  
 - (1E+3) - 2E-9 - -  
52 Tellurium-125m D, see 116Te 1E+3 4E+2 2E-7 - - -  
 Bone surf Bone surf  
 (1E+3) (1E+3) - 1E-9 2E-5 2E-4  
 W, see 116Te - 7E+2 3E-7 1E-9 - -  
52 Tellurium-127m D, see 116Te 6E+2 3E+2 1E-7 - 9E-6 9E-5  
 Bone surf  
 - (4E+2) - 6E-10 - -  
 W, see 116Te - 3E+2 1E-7 4E-10 - -  
52 Tellurium-127 D, see 116Te 7E+3 2E+4 9E-6 3E-8 1E-4 1E-3  
 W, see 116Te - 2E+4 7E-6 2E-8 - -  
52 Tellurium-129m D, see 116Te 5E+2 6E+2 3E-7 9E-10 7E-6 7E-5  
 W, see 116Te - 2E+2 1E-7 3E-10 - -  
52 Tellurium-1292 D, see 116Te 3E+4 6E+4 3E-5 9E-8 4E-4 4E-3  
 W, see 116Te - 7E+4 3E-5 1E-7 - -  
52 Tellurium-131m D, see 116Te 3E+2 4E+2 2E-7 - - -  
 Thyroid Thyroid  
 (6E+2) (1E+3) - 2E-9 8E-6 8E-5  
 W, see 116Te - 4E+2 2E-7 - - -  
 Thyroid  
 - (9E+2) - 1E-9 - -  
52 Tellurium-1312 D, see 116Te 3E+3 5E+3 2E-6 - - -  
 Thyroid Thyroid  
 (6E+3) (1E+4) - 2E-8 8E-5 8E-4  
 W, see 116Te - 5E+3 2E-6 - - -  
 Thyroid  
 - (1E+4) - 2E-8 - -  
52 Tellurium-132 D, see 116Te 2E+2 2E+2 9E-8 - - -  
 Thyroid Thyroid  
 (7E+2) (8E+2) - 1E-9 9E-6 9E-5  
 W, see 116Te - 2E+2 9E-8 - - -  
 Thyroid  
 - (6E+2) - 9E-10 - -  
52 Tellurium-133m2 D, see 116Te 3E+3 5E+3 2E-6 - - -  
 Thyroid Thyroid  
 (6E+3) (1E+4) - 2E-8 9E-5 9E-4  
 W, see 116Te - 5E+3 2E-6 - - -  
 Thyroid  
 - (1E+4) - 2E-8 - -  
52 Tellurium-1332 D, see 116Te 1E+4 2E+4 9E-6 - - -  
 Thyroid Thyroid  
 (3E+4) (6E+4) - 8E-8 4E-4 4E-3  
 W, see 116Te - 2E+4 9E-6 - - -  
 Thyroid  
 - (6E+4) - 8E-8 - -  
52 Tellurium-1342 D, see 116Te 2E+4 2E+4 1E-5 - - -  
 Thyroid Thyroid  
 (2E+4) (5E+4) - 7E-8 3E-4 3E-3  
 W, see 116Te - 2E+4 1E-5 - - -  
 Thyroid  
 - (5E+4) - 7E-8 - -  
53 Iodine-120m2 D, all compounds 1E+4 2E+4 9E-6 3E-8 - -  
 Thyroid   
 (1E+4) - - - 2E-4 2E-3  
53 Iodine-1202 D, all compounds 4E+3 9E+3 4E-6 - - -  
 Thyroid Thyroid  
 (8E+3) (1E+4) - 2E-8 1E-4 1E-3

Table I Table II Table III  
 Effluent Releases to  
 Occupational Values Concentrations Sewers

Col. 1 Col. 2 Col. 3 Col. 1 Col. 2  
 Oral Monthly  
 Ingestion Inhalation Average  
Atomic ALI ALI DAC Air Water Concentration  
No. Radionuclide Class (Ci) (Ci) (Ci/ml) (Ci/ml) (Ci/ml) (Ci/ml)

53 Iodine-121 D, all compounds 1E+4 2E+4 8E-6 - - -  
 Thyroid Thyroid  
 (3E+4) (5E+4) - 7E-8 4E-4 4E-3  
53 Iodine-123 D, all compounds 3E+3 6E+3 3E-6 - - -  
 Thyroid Thyroid  
 (1E+4) (2E+4) - 2E-8 1E-4 1E-3  
53 Iodine-124 D, all compounds 5E+1 8E+1 3E-8 - - -  
 Thyroid Thyroid  
 (2E+2) (3E+2) - 4E-10 2E-6 2E-5  
53 Iodine-125 D, all compounds 4E+1 6E+1 3E-8 - - -  
 Thyroid Thyroid  
 (1E+2) (2E+2) - 3E-10 2E-6 2E-5  
53 Iodine-126 D, all compounds 2E+1 4E+1 1E-8 - - -  
 Thyroid Thyroid  
 (7E+1) (1E+2) - 2E-10 1E-6 1E-5  
53 Iodine-1282 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 Thyroid  
 (2E+1) (3E+1) - 4E-11 2E-7 2E-6  
53 Iodine-130 D, all compounds 4E+2 7E+2 3E-7 - - -  
 Thyroid Thyroid  
 (1E+3) (2E+3) - 3E-9 2E-5 2E-4  
53 Iodine-131 D, all compounds 3E+1 5E+1 2E-8 - - -  
 Thyroid Thyroid  
 (9E+1) (2E+2) - 2E-10 1E-6 1E-5  
53 Iodine-132m2 D, all compounds 4E+3 8E+3 4E-6 - - -  
 Thyroid Thyroid  
 (1E+4) (2E+4) - 3E-8 1E-4 1E-3  
53 Iodine-132 D, all compounds 4E+3 8E+3 3E-6 - - -  
 Thyroid Thyroid  
 (9E+3) (1E+4) - 2E-8 1E-4 1E-3  
53 Iodine-133 D, all compounds 1E+2 3E+2 1E-7 - - -  
 Thyroid Thyroid  
 (5E+2) (9E+2) - 1E-9 7E-6 7E-5  
53 Iodine-1342 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 Thyroid  
 (3E+3) (4E+3) - 6E-9 3E-5 3E-4  
54 Xenon-1202 Submersion1 - - 1E-5 4E-8 - -  
54 Xenon-1212 Submersion1 - - 2E-6 1E-8 - -  
54 Xenon-122 Submersion1 - - 7E-5 3E-7 - -  
54 Xenon-123 Submersion1 - - 6E-6 3E-8 - -  
54 Xenon-125 Submersion1 - - 2E-5 7E-8 - -  
54 Xenon-127 Submersion1 - - 1E-5 6E-8 - -  
54 Xenon-129m Submersion1 - - 2E-4 9E-7 - -  
54 Xenon-131m Submersion1 - - 4E-4 2E-6 - -  
54 Xenon-133m Submersion1 - - 1E-4 6E-7 - -  
54 Xenon-133 Submersion1 - - 1E-4 5E-7 - -  
54 Xenon-135m2 Submersion1 - - 9E-6 4E-8 - -  
54 Xenon-135 Submersion1 - - 1E-5 7E-8 - -  
54 Xenon-138² Submersion1 - - 4E-6 2E-8 - -  
55 Cesium-1252 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-1302 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-135m2 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  
55 Cesium-137 D, all compounds 1E+2 2E+2 6E-8 2E-10 1E-6 1E-5  
55 Cesium-1382 D, all compounds 2E+4 6E+4 2E-5 8E-8 - -  
 St wall  
 (3E+4) - - - 4E-4 4E-3  
56 Barium-126² 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-131m2 D, all compounds 4E+5 1E+6 6E-4 2E-6 - -  
 St wall  
 (5E+5) - - - 7E-3 7E-2

Table I Table II Table III  
 Effluent Releases to  
 Occupational Values Concentrations Sewers

Col. 1 Col. 2 Col. 3 Col. 1 Col. 2  
 Oral Monthly  
 Ingestion Inhalation Average  
Atomic ALI ALI DAC Air Water Concentration  
No. Radionuclide Class (Ci) (Ci) (Ci/ml) (Ci/ml) (Ci/ml) (Ci/ml)

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-1392 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-1412 D, all compounds 2E+4 7E+4 3E-5 1E-7 3E-4 3E-3  
56 Barium-1422 D, all compounds 5E+4 1E+5 6E-5 2E-7 7E-4 7E-3  
57 Lanthanum-1312 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 131La 3E+3 1E+4 4E-6 1E-8 4E-5 4E-4  
 W, see 131La - 1E+4 5E-6 2E-8 - -  
57 Lanthanum-135 D, see 131La 4E+4 1E+5 4E-5 1E-7 5E-4 5E-3  
 W, see 131La - 9E+4 4E-5 1E-7 - -  
57 Lanthanum-137 D, see 131La 1E+4 6E+1 3E-8 - 2E-4 2E-3  
 Liver  
 - (7E+1) - 1E-10 - -  
 W, see 131La - 3E+2 1E-7 - - -  
 Liver  
 - (3E+2) - 4E-10 - -  
57 Lanthanum-138 D, see 131La 9E+2 4E+0 1E-9 5E-12 1E-5 1E-4  
 W, see 131La - 1E+1 6E-9 2E-11 - -  
57 Lanthanum-140 D, see 131La 6E+2 1E+3 6E-7 2E-9 9E-6 9E-5  
 W, see 131La - 1E+3 5E-7 2E-9 - -  
57 Lanthanum-141 D, see 131La 4E+3 9E+3 4E-6 1E-8 5E-5 5E-4  
 W, see 131La - 1E+4 5E-6 2E-8 - -  
57 Lanthanum-1422 D, see 131La 8E+3 2E+4 9E-6 3E-8 1E-4 1E-3  
 W, see 131La - 3E+4 1E-5 5E-8 - -  
57 Lanthanum-1432 D, see 131La 4E+4 1E+5 4E-5 1E-7 - -  
 St wall   
 (4E+4) - - - 5E-4 5E-3  
 W, see 131La - 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 134Ce 2E+3 4E+3 2E-6 5E-9 2E-5 2E-4  
 Y, see 134Ce - 4E+3 1E-6 5E-9 - -  
58 Cerium-137m W, see 134Ce 2E+3 4E+3 2E-6 6E-9 - -  
 LLI wall  
 (2E+3) - - - 3E-5 3E-4  
 Y, see 134Ce - 4E+3 2E-6 5E-9 - -  
58 Cerium-137 W, see 134Ce 5E+4 1E+5 6E-5 2E-7 7E-4 7E-3  
 Y, see 134Ce - 1E+5 5E-5 2E-7 - -  
58 Cerium-139 W, see 134Ce 5E+3 8E+2 3E-7 1E-9 7E-5 7E-4  
 Y, see 134Ce - 7E+2 3E-7 9E-10 - -  
58 Cerium-141 W, see 134Ce 2E+3 7E+2 3E-7 1E-9 - -  
 LLI wall  
 (2E+3) - - - 3E-5 3E-4  
 Y, see 134Ce - 6E+2 2E-7 8E-10 - -

58 Cerium-143 W, see 134Ce 1E+3 2E+3 8E-7 3E-9 - -  
 LLI wall  
 (1E+3) - - - 2E-5 2E-4

Y, see 134Ce - 2E+3 7E-7 2E-9 - -  
58 Cerium-144 W, see 134Ce 2E+2 3E+1 1E-8 4E-11 - -  
 LLI wall  
 (3E+2) - - - 3E-6 3E-5  
 Y, see 134Ce - 1E+1 6E-9 2E-11 - -  
59 Praseodymium-1362 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-1372 W, see 136Pr 4E+4 2E+5 6E-5 2E-7 5E-4 5E-3  
 Y, see 136Pr - 1E+5 6E-5 2E-7 - -

59 Praseodymium-138m W, see 136Pr 1E+4 5E+4 2E-5 8E-8 1E-4 1E-3  
 Y, see 136Pr - 4E+4 2E-5 6E-8 - -  
59 Praseodymium-139 W, see 136Pr 4E+4 1E+5 5E-5 2E-7 6E-4 6E-3  
 Y, see 136Pr - 1E+5 5E-5 2E-7 - -

Table I Table II Table III  
 Effluent Releases to  
 Occupational Values Concentrations Sewers

Col. 1 Col. 2 Col. 3 Col. 1 Col. 2  
 Oral Monthly  
 Ingestion Inhalation Average  
Atomic ALI ALI DAC Air Water Concentration  
No. Radionuclide Class (Ci) (Ci) (Ci/ml) (Ci/ml) (Ci/ml) (Ci/ml)

59 Praseodymium-142m2 W, see 136Pr 8E+4 2E+5 7E-5 2E-7 1E-3 1E-2  
 Y, see 136Pr - 1E+5 6E-5 2E-7 - -  
59 Praseodymium-142 W, see 136Pr 1E+3 2E+3 9E-7 3E-9 1E-5 1E-4  
 Y, see 136Pr - 2E+3 8E-7 3E-9 - -  
59 Praseodymium-143 W, see 136Pr 9E+2 8E+2 3E-7 1E-9 - -  
 LLI wall  
 (1E+3) - - - 2E-5 2E-4  
 Y, see 136Pr - 7E+2 3E-7 9E-10 - -  
59 Praseodymium-1442 W, see 136Pr 3E+4 1E+5 5E-5 2E-7 - -  
 St wall  
 (4E+4) - - - 6E-4 6E-3  
 Y, see 136Pr - 1E+5 5E-5 2E-7 - -  
59 Praseodymium-145 W, see 136Pr 3E+3 9E+3 4E-6 1E-8 4E-5 4E-4  
 Y, see 136Pr - 8E+3 3E-6 1E-8 - -  
59 Praseodymium-1472  W, see 136Pr 5E+4 2E+5 8E-5 3E-7 - -  
 St wall  
 (8E+4) - - - 1E-3 1E-2  
 Y, see 136Pr - 2E+5 8E-5 3E-7 - -  
60 Neodymium-1362 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 136Nd 2E+3 6E+3 3E-6 9E-9 3E-5 3E-4  
 Y, see 136Nd - 5E+3 2E-6 7E-9 - -  
60 Neodymium-139m W, see 136Nd 5E+3 2E+4 7E-6 2E-8 7E-5 7E-4  
 Y, see 136Nd - 1E+4 6E-6 2E-8 - -  
60 Neodymium-1392 W, see 136Nd 9E+4 3E+5 1E-4 5E-7 1E-3 1E-2  
 Y, see 136Nd - 3E+5 1E-4 4E-7 - -  
60 Neodymium-141 W, see 136Nd 2E+5 7E+5 3E-4 1E-6 2E-3 2E-2  
 Y, see 136Nd - 6E+5 3E-4 9E-7 - -  
60 Neodymium-147 W, see 136Nd 1E+3 9E+2 4E-7 1E-9 - -  
 LLI wall  
 (1E+3) - - - 2E-5 2E-4  
 Y, see 136Nd - 8E+2 4E-7 1E-9 - -  
60 Neodymium-1492 W, see 136Nd 1E+4 3E+4 1E-5 4E-8 1E-4 1E-3  
 Y, see 136Nd - 2E+4 1E-5 3E-8 - -  
60 Neodymium-1512 W, see 136Nd 7E+4 2E+5 8E-5 3E-7 9E-4 9E-3  
 Y, see 136Nd - 2E+5 8E-5 3E-7 - -  
61 Promethium-1412 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 141Pm 5E+3 6E+2 2E-7 8E-10 7E-5 7E-4  
 Y, see 141Pm - 7E+2 3E-7 1E-9 - -  
61 Promethium-144 W, see 141Pm 1E+3 1E+2 5E-8 2E-10 2E-5 2E-4  
 Y, see 141Pm - 1E+2 5E-8 2E-10 - -  
61 Promethium-145 W, see 141Pm 1E+4 2E+2 7E-8 - 1E-4 1E-3  
 Bone surf  
 - (2E+2) - 3E-10 - -  
 Y, see 141Pm - 2E+2 8E-8 3E-10 - -  
61 Promethium-146 W, see 141Pm 2E+3 5E+1 2E-8 7E-11 2E-5 2E-4  
 Y, see 141Pm - 4E+1 2E-8 6E-11 - -  
61 Promethium-147 W, see 141Pm 4E+3 1E+2 5E-8 - - -  
 LLI wall Bone surf  
 (5E+3) (2E+2) - 3E-10 7E-5 7E-4  
 Y, see 141Pm - 1E+2 6E-8 2E-10 - -

61 Promethium-148m W, see 141Pm 7E+2 3E+2 1E-7 4E-10 1E-5 1E-4  
 Y, see 141Pm - 3E+2 1E-7 5E-10 - -  
61 Promethium-148 W, see 141Pm 4E+2 5E+2 2E-7 8E-10 - -  
 LLI wall  
 (5E+2) - - - 7E-6 7E-5  
 Y, see 141Pm - 5E+2 2E-7 7E-10 - -  
61 Promethium-149 W, see 141Pm 1E+3 2E+3 8E-7 3E-9 - -  
 LLI wall   
 (1E+3) - - - 2E-5 2E-4  
 Y, see 141Pm - 2E+3 8E-7 2E-9 - -  
61 Promethium-150 W, see 141Pm 5E+3 2E+4 8E-6 3E-8 7E-5 7E-4  
 Y, see 141Pm - 2E+4 7E-6 2E-8 - -  
61 Promethium-151 W, see 141Pm 2E+3 4E+3 1E-6 5E-9 2E-5 2E-4  
 Y, see 141Pm - 3E+3 1E-6 4E-9 - -

62 Samarium-141m2 W, all compounds 3E+4 1E+5 4E-5 1E-7 4E-4 4E-3  
62 Samarium-1412 W, all compounds 5E+4 2E+5 8E-5 2E-7 - -  
 St wall  
 (6E+4) - - - 8E-4 8E-3

Table I Table II Table III  
 Effluent Releases to  
 Occupational Values Concentrations Sewers

Col. 1 Col. 2 Col. 3 Col. 1 Col. 2  
 Oral Monthly  
 Ingestion Inhalation Average  
Atomic ALI ALI DAC Air Water Concentration  
No. Radionuclide Class (Ci) (Ci) (Ci/ml) (Ci/ml) (Ci/ml) (Ci/ml)

62 Samarium-1422 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 4E2 1E-11 - - -  
 Bone surf Bone surf  
 (3E+1) (6E-2) - 9E-14 3E-7 3E-6  
62 Samarium-147 W, all compounds 2E+1 4E2 2E-11 - - -  
 Bone surf Bone surf  
 (3E+1) (7E-2) - 1E-13 4E-7 4E-6  
62 Samarium-151 W, all compounds 1E+4 1E+2 4E-8 - - -  
 LLI wall Bone surf  
 (1E+4) (2E+2) - 2E-10 2E-4 2E-3  
62 Samarium-153 W, all compounds 2E+3 3E+3 1E-6 4E-9 - -  
 LLI wall  
 (2E+3) - - - 3E-5 3E-4  
62 Samarium-1552 W, all compounds 6E+4 2E+5 9E-5 3E-7 - -  
 St wall  
 (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 W, all compounds 3E+3 8E+3 4E-6 1E-8 4E-5 4E-4  
 (12.62 h)  
63 Europium-150 W, all compounds 8E+2 2E+1 8E-9 3E-11 1E-5 1E-4  
 (34.2 y)  
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-1582 W, all compounds 2E+4 6E+4 2E-5 8E-8 3E-4 3E-3  
64 Gadolinium-1452 D, all compounds except  
 those given for W 5E+4 2E+5 6E-5 2E-7 - -  
 St wall  
 (5E+4) - - - 6E-4 6E-3  
 W, oxides, hydroxides,  
 and fluorides - 2E+5 7E-5 2E-7 - -

64 Gadolinium-146 D, see 145Gd 1E+3 1E+2 5E-8 2E-10 2E-5 2E-4  
 W, see 145Gd - 3E+2 1E-7 4E-10 - -  
64 Gadolinium-147 D, see 145Gd 2E+3 4E+3 2E-6 6E-9 3E-5 3E-4  
 W, see 145Gd - 4E+3 1E-6 5E-9 - -  
64 Gadolinium-148 D, see 145Gd 1E+1 8E+3 3E-12 - - -  
 Bone surf Bone surf  
 (2E+1) (2E+2) - 2E-14 3E-7 3E-6  
 W, see 145Gd - 3E-2 1E-11 - - -  
 Bone surf  
 - (6E-2) - 8E-14 - -  
64 Gadolinium-149 D, see 145Gd 3E+3 2E+3 9E-7 3E-9 4E-5 4E-4  
 W, see 145Gd - 2E+3 1E-6 3E-9 - -  
64 Gadolinium-151 D, see 145Gd 6E+3 4E+2 2E-7 - 9E-5 9E-4  
 Bone surf  
 - (6E+2) - 9E-10 - -  
 W, see 145Gd - 1E+3 5E-7 2E-9 - -  
64 Gadolinium-152 D, see 145Gd 2E+1 1E-2 4E-12 - - -  
 Bone surf Bone surf  
 (3E+1) (2E-2) - 3E-14 4E-7 4E-6  
 W, see 145Gd - 4E-2 2E-11 - - -  
 Bone surf

64 Gadolinium-153 D, see 145Gd 5E+3 1E+2 6E-8 - 6E-5 6E-4  
 Bone surf  
 - (2E+2) - 3E-10 - -  
 W, see 145Gd - 6E+2 2E-7 8E-10 - -  
64 Gadolinium-159 D, see 145Gd 3E+3 8E+3 3E-6 1E-8 4E-5 4E-4  
 W, see 145Gd - 6E+3 2E-6 8E-9 - -  
65 Terbium-1472 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

Table I Table II Table III  
 Effluent Releases to  
 Occupational Values Concentrations Sewers

Col. 1 Col. 2 Col. 3 Col. 1 Col. 2  
 Oral Monthly  
 Ingestion Inhalation Average  
Atomic ALI ALI DAC Air Water Concentration  
No. Radionuclide Class (Ci) (Ci) (Ci/ml) (Ci/ml) (Ci/ml) (Ci/ml)

65 Terbium-156m W, all compounds 2E+4 3E+4 1E-5 4E-8 2E-4 2E-3  
 (5.0 h)  
65 Terbium-156m W, all compounds 7E+3 8E+3 3E-6 1E-8 1E-4 1E-3  
 (24.4 h)  
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 Bone surf  
 (5E+4) (6E+2) - 8E-10 7E-4 7E-3  
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-1552 W, all compounds 4E+4 2E+5 6E-5 2E-7 6E-4 6E-3  
67 Holmium-1572 W, all compounds 3E+5 1E+6 6E-4 2E-6 4E-3 4E-2  
67 Holmium-1592 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-162m2 W, all compounds 5E+4 3E+5 1E-4 4E-7 7E-4 7E-3  
67 Holmium-1622 W, all compounds 5E+5 2E+6 1E-3 3E-6 - -  
 St wall   
 (8E+5) - - - 1E-2 1E-1  
67 Holmium-164m2 W, all compounds 1E+5 3E+5 1E-4 4E-7 1E-3 1E-2  
67 Holmium-164² 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-1622 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  
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 Bone surf  
 (1E+4) (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-1752 W, all compounds 7E+4 3E+5 1E-4 4E-7 - -  
 St wall  
 (9E+4) - - - 1E-3 1E-2  
70 Ytterbium-1622 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 162Yb 1E+3 2E+3 8E-7 3E-9 2E-5 2E-4  
 Y, see 162Yb - 2E+3 8E-7 3E-9 - -  
70 Ytterbium-1672 W, see 162Yb 3E+5 8E+5 3E-4 1E-6 4E-3 4E-2  
 Y, see 162Yb - 7E+5 3E-4 1E-6 - -  
70 Ytterbium-169 W, see 162Yb 2E+3 8E+2 4E-7 1E-9 2E-5 2E-4  
 Y, see 162Yb - 7E+2 3E-7 1E-9 - -

Table I Table II Table III  
 Effluent Releases to  
 Occupational Values Concentrations Sewers

Col. 1 Col. 2 Col. 3 Col. 1 Col. 2  
 Oral Monthly  
 Ingestion Inhalation Average  
Atomic ALI ALI DAC Air Water Concentration  
No. Radionuclide Class (Ci) (Ci) (Ci/ml) (Ci/ml) (Ci/ml) (Ci/ml)

70 Ytterbium-175 W, see 162Yb 3E+3 4E+3 1E-6 5E-9 - -  
 LLI wall  
 (3E+3) - - - 4E-5 4E-4  
 Y, see 162Yb - 3E+3 1E-6 5E-9 - -  
70 Ytterbium-1772 W, see 162Yb 2E+4 5E+4 2E-5 7E-8 2E-4 2E-3  
 Y, see 162Yb - 5E+4 2E-5 6E-8 - -  
70 Ytterbium-1782 W, see 162Yb 1E+4 4E+4 2E-5 6E-8 2E-4 2E-3  
 Y, see 162Yb - 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 169Lu 1E+3 2E+3 9E-7 3E-9 2E-5 2E-4  
 Y, see 169Lu - 2E+3 8E-7 3E-9 - -  
71 Lutetium-171 W, see 169Lu 2E+3 2E+3 8E-7 3E-9 3E-5 3E-4  
 Y, see 169Lu - 2E+3 8E-7 3E-9 - -  
71 Lutetium-172 W, see 169Lu 1E+3 1E+3 5E-7 2E-9 1E-5 1E-4  
 Y, see 169Lu - 1E+3 5E-7 2E-9 - -  
71 Lutetium-173 W, see 169Lu 5E+3 3E+2 1E-7 - 7E-5 7E-4  
 Bone surf  
 - (5E+2) - 6E-10 - -  
 Y, see 169Lu - 3E+2 1E-7 4E-10 - -  
71 Lutetium-174m W, see 169Lu 2E+3 2E+2 1E-7 - - -  
 LLI wall Bone surf  
 (3E+3) (3E+2) - 5E-10 4E-5 4E-4  
 Y, see 169Lu - 2E+2 9E-8 3E-10 - -  
71 Lutetium-174 W, see 169Lu 5E+3 1E+2 5E-8 - 7E-5 7E-4  
 Bone surf  
 - (2E+2) - 3E-10 - -  
 Y, see 169Lu - 2E+2 6E-8 2E-10 - -  
71 Lutetium-176m W, see 169Lu 8E+3 3E+4 1E-5 3E-8 1E-4 1E-3  
 Y, see 169Lu - 2E+4 9E-6 3E-8 - -  
71 Lutetium-176 W, see 169Lu 7E+2 5E+0 2E-9 - 1E-5 1E-4  
 Bone surf  
 - (1E+1) - 2E-11 - -  
 Y, see 169Lu - 8E+0 3E-9 1E-11 - -  
71 Lutetium-177m W, see 169Lu 7E+2 1E+2 5E-8 - 1E-5 1E-4  
 Bone surf  
 - (1E+2) - 2E-10 - -  
 Y, see 169Lu - 8E+1 3E-8 1E-10 - -  
71 Lutetium-177 W, see 169Lu 2E+3 2E+3 9E-7 3E-9 - -  
 LLI wall  
 (3E+3) - - - 4E-5 4E-4  
 Y, see 169Lu - 2E+3 9E-7 3E-9 - -  
71 Lutetium-178m2 W, see 169Lu 5E+4 2E+5 8E-5 3E-7 - -  
 St. wall  
 (6E+4) - - - 8E-4 8E-3  
 Y, see 169Lu - 2E+5 7E-5 2E-7 - -  
71 Lutetium-1782 W, see 169Lu 4E+4 1E+5 5E-5 2E-7 - -  
 St wall  
 (4E+4) - - - 6E-4 6E-3  
 Y, see 169Lu - 1E+5 5E-5 2E-7 - -  
71 Lutetium-179 W, see 169Lu 6E+3 2E+4 8E-6 3E-8 9E-5 9E-4  
 Y, see 169Lu - 2E+4 6E-6 3E-8 - -  
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 170Hf 1E+3 9E+0 4E-9 - 2E-5 2E-4  
 Bone surf  
 - (2E+1) - 3E-11 - -  
 W, see 170Hf - 4E+1 2E-8 - - -  
 Bone surf  
 - (6E+1) - 8E-11 - -  
72 Hafnium-173 D, see 170Hf 5E+3 1E+4 5E-6 2E-8 7E-5 7E-4  
 W, see 170Hf - 1E+4 5E-6 2E-8 - -  
72 Hafnium-175 D, see 170Hf 3E+3 9E+2 4E-7 - 4E-5 4E-4  
 Bone surf  
 - (1E+3) - 1E-9 - -  
 W, see 170Hf - 1E+3 5E-7 2E-9 - -

Table I Table II Table III  
 Effluent Releases to  
 Occupational Values Concentrations Sewers

Col. 1 Col. 2 Col. 3 Col. 1 Col. 2  
 Oral Monthly  
 Ingestion Inhalation Average  
Atomic ALI ALI DAC Air Water Concentration  
No. Radionuclide Class (Ci) (Ci) (Ci/ml) (Ci/ml) (Ci/ml) (Ci/ml)

72 Hafnium-177m2 D, see 170Hf 2E+4 6E+4 2E-5 8E-8 3E-4 3E-3  
 W, see 170Hf - 9E+4 4E-5 1E-7 - -  
72 Hafnium-178m D, see 170Hf 3E+2 1E+0 5E-10 - 3E-6 3E-5  
 Bone surf  
 - (2E+0) - 3E-12 - -  
 W, see 170Hf - 5E+0 2E-9 - - -  
 Bone surf  
 - (9E+0) - 1E-11 - -  
72 Hafnium-179m D, see 170Hf 1E+3 3E+2 1E-7 - 1E-5 1E-4  
 Bone surf  
 - (6E+2) - 8E-10 - -  
 W, see 170Hf - 6E+2 3E-7 8E-10 - -  
72 Hafnium-180m D, see 170Hf 7E+3 2E+4 9E-6 3E-8 1E-4 1E-3  
 W, see 170Hf - 3E+4 1E-5 4E-8 - -  
72 Hafnium-181 D, see 170Hf 1E+3 2E+2 7E-8 - 2E-5 2E-4  
 Bone surf  
 - (4E+2) - 6E-10 - -  
 W, see 170Hf - 4E+2 2E-7 6E-10 - -  
72 Hafnium-182m2 D, see 170Hf 4E+4 9E+4 4E-5 1E-7 5E-4 5E-3  
 W, see 170Hf - 1E+5 6E-5 2E-7 - -  
72 Hafnium-182 D, see 170Hf 2E+2 8E-1 3E-10 - - -  
 Bone surf Bone surf  
 (4E+2) (2E+0) - 2E-12 5E-6 5E-5  
 W, see 170Hf - 3E+0 1E-9 - - -  
 Bone surf  
 - (7E+0) - 1E-11 - -  
72 Hafnium-1832 D, see 170Hf 2E+4 5E+4 2E-5 6E-8 3E-4 3E-3  
 W, see 170Hf - 6E+4 2E-5 8E-8 - -  
72 Hafnium-184 D, see 170Hf 2E+3 8E+3 3E-6 1E-8 3E-5 3E-4  
 W, see 170Hf - 6E+3 3E-6 9E-9 - -  
73 Tantalum-1722 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 172Ta 7E+3 2E+4 8E-6 3E-8 9E-5 9E-4  
 Y, see 172Ta - 2E+4 7E-6 2E-8 - -  
73 Tantalum-1742 W, see 172Ta 3E+4 1E+5 4E-5 1E-7 4E-4 4E-3  
 Y, see 172Ta - 9E+4 4E-5 1E-7 - -  
73 Tantalum-175 W, see 172Ta 6E+3 2E+4 7E-6 2E-8 8E-5 8E-4  
 Y, see 172Ta - 1E+4 6E-6 2E-8 - -  
73 Tantalum-176 W, see 172Ta 4E+3 1E+4 5E-6 2E-8 5E-5 5E-4  
 Y, see 172Ta - 1E+4 5E-6 2E-8 - -  
73 Tantalum-177 W, see 172Ta 1E+4 2E+4 8E-6 3E-8 2E-4 2E-3  
 Y, see 172Ta - 2E+4 7E-6 2E-8 - -  
73 Tantalum-178 W, see 172Ta 2E+4 9E+4 4E-5 1E-7 2E-4 2E-3  
 Y, see 172Ta - 7E+4 3E-5 1E-7 - -  
73 Tantalum-179 W, see 172Ta 2E+4 5E+3 2E-6 8E-9 3E-4 3E-3  
 Y, see 172Ta - 9E+2 4E-7 1E-9 - -  
73 Tantalum-180m W, see 172Ta 2E+4 7E+4 3E-5 9E-8 3E-4 3E-3  
 Y, see 172Ta - 6E+4 2E-5 8E-8 - -  
73 Tantalum-180 W, see 172Ta 1E+3 4E+2 2E-7 6E-10 2E-5 2E-4  
 Y, see 172Ta - 2E+1 1E-8 3E-11 - -  
73 Tantalum-182m2 W, see 172Ta 2E+5 5E+5 2E-4 8E-7 - -  
 St wall  
 (2E+5) - - - 3E-3 3E-2  
 Y, see 172Ta - 4E+5 2E-4 6E-7 - -  
73 Tantalum-182 W, see 172Ta 8E+2 3E+2 1E-7 5E-10 1E-5 1E-4  
 Y, see 172Ta - 1E+2 6E-8 2E-10 - -  
73 Tantalum-183 W, see 172Ta 9E+2 1E+3 5E-7 2E-9 - -  
 LLI wall  
 (1E+3) - - - 2E-5 2E-4  
 Y, see 172Ta - 1E+3 4E-7 1E-9 - -  
73 Tantalum-184 W, see 172Ta 2E+3 5E+3 2E-6 8E-9 3E-5 3E-4  
 Y, see 172Ta - 5E+3 2E-6 7E-9 - -  
73 Tantalum-1852 W, see 172Ta 3E+4 7E+4 3E-5 1E-7 4E-4 4E-3  
 Y, see 172Ta - 6E+4 3E-5 9E-8 - -  
73 Tantalum-1862 W, see 172Ta 5E+4 2E+5 1E-4 3E-7 - -  
 St wall  
 (7E+4) - - - 1E-3 1E-2  
 Y, see 172Ta - 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-1792 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

Table I Table II Table III  
 Effluent Releases to  
 Occupational Values Concentrations Sewers

Col. 1 Col. 2 Col. 3 Col. 1 Col. 2  
 Oral Monthly  
 Ingestion Inhalation Average  
Atomic ALI ALI DAC Air Water Concentration  
No. Radionuclide Class (Ci) (Ci) (Ci/ml) (Ci/ml) (Ci/ml) (Ci/ml)

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-1772 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-1782 D, see 177Re 7E+4 3E+5 1E-4 4E-7 - -  
 St wall  
 (1E+5) - - - 1E-3 1E-2  
 W, see 177Re - 3E+5 1E-4 4E-7 - -  
75 Rhenium-181 D, see 177Re 5E+3 9E+3 4E-6 1E-8 7E-5 7E-4  
 W, see 177Re - 9E+3 4E-6 1E-8 - -  
75 Rhenium-182 D, see 177Re 7E+3 1E+4 5E-6 2E-8 9E-5 9E-4  
 (12.7 h) W, see 177Re - 2E+4 6E-6 2E-8 - -  
75 Rhenium-182 D, see 177Re 1E+3 2E+3 1E-6 3E-9 2E-5 2E-4  
 (64.0 h) W, see 177Re - 2E+3 9E-7 3E-9 - -  
75 Rhenium-184m D, see 177Re 2E+3 3E+3 1E-6 4E-9 3E-5 3E-4  
 W, see 177Re - 4E+2 2E-7 6E-10 - -  
75 Rhenium-184 D, see 177Re 2E+3 4E+3 1E-6 5E-9 3E-5 3E-4  
 W, see 177Re - 1E+3 6E-7 2E-9 - -  
75 Rhenium-186m D, see 177Re 1E+3 2E+3 7E-7 - - -  
 St wall St wall  
 (2E+3) (2E+3) - 3E-9 2E-5 2E-4  
 W, see 177Re - 2E+2 6E-8 2E-10 - -  
75 Rhenium-186 D, see 177Re 2E+3 3E+3 1E-6 4E-9 3E-5 3E-4  
 W, see 177Re - 2E+3 7E-7 2E-9 - -  
75 Rhenium-187 D, see 177Re 6E+5 8E+5 4E-4 - 8E-3 8E-2  
 St wall  
 - (9E+5) - 1E-6 - -  
 W, see 177Re - 1E+5 4E-5 1E-7 - -  
75 Rhenium-188m2 D, see 177Re 8E+4 1E+5 6E-5 2E-7 1E-3 1E-2  
 W, see 177Re - 1E+5 6E-5 2E-7 - -  
75 Rhenium-188 D, see 177Re 2E+3 3E+3 1E-6 4E-9 2E-5 2E-4  
 W, see 177Re - 3E+3 1E-6 4E-9 - -  
75 Rhenium-189 D, see 177Re 3E+3 5E+3 2E-6 7E-9 4E-5 4E-4  
 W, see 177Re - 4E+3 2E-6 6E-9 - -  
76 Osmium-1802 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 - -  
 Y, oxides and hydroxides - 5E+5 2E-4 6E-7 - -  
76 Osmium-1812 D, see 180Os 1E+4 4E+4 2E-5 6E-8 2E-4 2E-3  
 W, see 180Os - 5E+4 2E-5 6E-8 - -  
 Y, see 180Os - 4E+4 2E-5 6E-8 - -  
76 Osmium-182 D, see 180Os 2E+3 6E+3 2E-6 8E-9 3E-5 3E-4  
 W, see 180Os - 4E+3 2E-6 6E-9 - -  
 Y, see 180Os - 4E+3 2E-6 6E-9 - -  
76 Osmium-185 D, see 180Os 2E+3 5E+2 2E-7 7E-10 3E-5 3E-4  
 W, see 180Os - 8E+2 3E-7 1E-9 - -  
 Y, see 180Os - 8E+2 3E-7 1E-9 - -  
76 Osmium-189m D, see 180Os 8E+4 2E+5 1E-4 3E-7 1E-3 1E-2  
 W, see 180Os - 2E+5 9E-5 3E-7 - -  
 Y, see 180Os - 2E+5 7E-5 2E-7 - -  
76 Osmium-191m D, see 180Os 1E+4 3E+4 1E-5 4E-8 2E-4 2E-3  
 W, see 180Os - 2E+4 8E-6 3E-8 - -  
 Y, see 180Os - 2E+4 7E-6 2E-8 - -  
76 Osmium-191 D, see 180Os 2E+3 2E+3 9E-7 3E-9 - -  
 LLI wall   
 (3E+3) - - - 3E-5 3E-4  
 W, see 180Os - 2E+3 7E-7 2E-9 - -  
 Y, see 180Os - 1E+3 6E-7 2E-9 - -  
76 Osmium-193 D, see 180Os 2E+3 5E+3 2E-6 6E-9 - -  
 LLI wall   
 (2E+3) - - - 2E-5 2E-4  
 W, see 180Os - 3E+3 1E-6 4E-9 - -  
 Y, see 180Os - 3E+3 1E-6 4E-9 - -  
76 Osmium-194 D, see 180Os 4E+2 4E+1 2E-8 6E-11 - -  
 LLI wall   
 (6E+2) - - - 8E-6 8E-5  
 W, see 180Os - 6E+1 2E-8 8E-11 - -  
 Y, see 180Os - 8E+0 3E-9 1E-11 - -  
77 Iridium-1822 D, all compounds except  
 those given for W and Y 4E+4 1E+5 6E-5 2E-7 - -  
 St wall  
 (4E+4) - - - 6E-4 6E-3  
 W, halides, nitrates,  
 and metallic iridium - 2E+5 6E-5 2E-7 - -  
 Y, oxides and hydroxides - 1E+5 5E-5 2E-7 - -

Table I Table II Table III  
 Effluent Releases to  
 Occupational Values Concentrations Sewers

Col. 1 Col. 2 Col. 3 Col. 1 Col. 2  
 Oral Monthly  
 Ingestion Inhalation Average  
Atomic ALI ALI DAC Air Water Concentration  
No. Radionuclide Class (Ci) (Ci) (Ci/ml) (Ci/ml) (Ci/ml) (Ci/ml)

77 Iridium-184 D, see 182Ir 8E+3 2E+4 1E-5 3E-8 1E-4 1E-3  
 W, see 182Ir - 3E+4 1E-5 5E-8 - -  
 Y, see 182Ir - 3E+4 1E-5 4E-8 - -  
77 Iridium-185 D, see 182Ir 5E+3 1E+4 5E-6 2E-8 7E-5 7E-4  
 W, see 182Ir - 1E+4 5E-6 2E-8 - -  
 Y, see 182Ir - 1E+4 4E-6 1E-8 - -  
77 Iridium-186 D, see 182Ir 2E+3 8E+3 3E-6 1E-8 3E-5 3E-4  
 W, see 182Ir - 6E+3 3E-6 9E-9 - -  
 Y, see 182Ir - 6E+3 2E-6 8E-9 - -  
77 Iridium-187 D, see 182Ir 1E+4 3E+4 1E-5 5E-8 1E-4 1E-3  
 W, see 182Ir - 3E+4 1E-5 4E-8 - -  
 Y, see 182Ir - 3E+4 1E-5 4E-8 - -  
77 Iridium-188 D, see 182Ir 2E+3 5E+3 2E-6 6E-9 3E-5 3E-4  
 W, see 182Ir - 4E+3 1E-6 5E-9 - -  
 Y, see 182Ir - 3E+3 1E-6 5E-9 - -  
77 Iridium-189 D, see 182Ir 5E+3 5E+3 2E-6 7E-9 - -  
 LLI wall  
 (5E+3) - - - 7E-5 7E-4  
 W, see 182Ir - 4E+3 2E-6 5E-9 - -  
 Y, see 182Ir - 4E+3 1E-6 5E-9 - -  
77 Iridium-190m2 D, see 182Ir 2E+5 2E+5 8E-5 3E-7 2E-3 2E-2  
 W, see 182Ir - 2E+5 9E-5 3E-7 - -  
 Y, see 182Ir - 2E+5 8E-5 3E-7 - -  
77 Iridium-190 D, see 182Ir 1E+3 9E+2 4E-7 1E-9 1E-5 1E-4  
 W, see 182Ir - 1E+3 4E-7 1E-9 - -  
 Y, see 182Ir - 9E+2 4E-7 1E-9 - -  
77 Iridium-192m D, see 182Ir 3E+3 9E+1 4E-8 1E-10 4E-5 4E-4  
 W, see 182Ir - 2E+2 9E-8 3E-10 - -  
 Y, see 182Ir - 2E+1 6E-9 2E-11 - -  
77 Iridium-192 D, see 182Ir 9E+2 3E+2 1E-7 4E-10 1E-5 1E-4  
 W, see 182Ir - 4E+2 2E-7 6E-10 - -  
 Y, see 182Ir - 2E+2 9E-8 3E-10 - -  
77 Iridium-194m D, see 182Ir 6E+2 9E+1 4E-8 1E-10 9E-6 9E-5  
 W, see 182Ir - 2E+2 7E-8 2E-10 - -  
 Y, see 182Ir - 1E+2 4E-8 1E-10 - -  
77 Iridium-194 D, see 182Ir 1E+3 3E+3 1E-6 4E-9 1E-5 1E-4  
 W, see 182Ir - 2E+3 9E-7 3E-9 - -  
 Y, see 182Ir - 2E+3 8E-7 3E-9 - -  
77 Iridium-195m D, see 182Ir 8E+3 2E+4 1E-5 3E-8 1E-4 1E-3  
 W, see 182Ir - 3E+4 1E-5 4E-8 - -  
 Y, see 182Ir - 2E+4 9E-6 3E-8 - -  
77 Iridium-195 D, see 182Ir 1E+4 4E+4 2E-5 6E-8 2E-4 2E-3  
 W, see 182Ir - 5E+4 2E-5 7E-8 - -  
 Y, see 182Ir - 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-197m2 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-1992 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  
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 193Au 3E+3 8E+3 3E-6 1E-8 4E-5 4E-4  
 W, see 193Au - 5E+3 2E-6 8E-9 - -  
 Y, see 193Au - 5E+3 2E-6 7E-9 - -  
79 Gold-195 D, see 193Au 5E+3 1E+4 5E-6 2E-8 7E-5 7E-4  
 W, see 193Au - 1E+3 6E-7 2E-9 - -  
 Y, see 193Au - 4E+2 2E-7 6E-10 - -  
79 Gold-198m D, see 193Au 1E+3 3E+3 1E-6 4E-9 1E-5 1E-4  
 W, see 193Au - 1E+3 5E-7 2E-9 - -  
 Y, see 193Au - 1E+3 5E-7 2E-9 - -

Table I Table II Table III  
 Effluent Releases to  
 Occupational Values Concentrations Sewers

Col. 1 Col. 2 Col. 3 Col. 1 Col. 2  
 Oral Monthly  
 Ingestion Inhalation Average  
Atomic ALI ALI DAC Air Water Concentration  
No. Radionuclide Class (Ci) (Ci) (Ci/ml) (Ci/ml) (Ci/ml) (Ci/ml)

79 Gold-198 D, see 193Au 1E+3 4E+3 2E-6 5E-9 2E-5 2E-4  
 W, see 193Au - 2E+3 8E-7 3E-9 - -  
 Y, see 193Au - 2E+3 7E-7 2E-9 - -  
79 Gold-199 D, see 193Au 3E+3 9E+3 4E-6 1E-8 - -  
 LLI wall  
 (3E+3) - - - 4E-5 4E-4  
 W, see 193Au - 4E+3 2E-6 6E-9 - -  
 Y, see 193Au - 4E+3 2E-6 5E-9 - -  
79 Gold-200m D, see 193Au 1E+3 4E+3 1E-6 5E-9 2E-5 2E-4  
 W, see 193Au - 3E+3 1E-6 4E-9 - -  
 Y, see 193Au - 2E+4 1E-6 3E-9 - -  
79 Gold-2002 D, see 193Au 3E+4 6E+4 3E-5 9E-8 4E-4 4E-3  
 W, see 193Au - 8E+4 3E-5 1E-7 - -  
 Y, see 193Au - 7E+4 3E-5 1E-7 - -  
79 Gold-2012 D, see 193Au 7E+4 2E+5 9E-5 3E-7 - -  
 St wall  
 (9E+4) - - - 1E-3 1E-2  
 W, see 193Au - 2E+5 1E-4 3E-7 - -  
 Y, see 193Au - 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 193mHg 2E+4 4E+4 2E-5 6E-8 2E-4 2E-3  
 W, see 193mHg - 4E+4 2E-5 6E-8 - -  
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 193mHg 8E+2 4E+1 2E-8 6E-11 1E-5 1E-4  
 W, see 193mHg - 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 193mHg 2E+3 5E+3 2E-6 7E-9 3E-5 3E-4  
 W, see 193mHg - 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 193mHg 1E+4 4E+4 1E-5 5E-8 2E-4 2E-3  
 W, see 193mHg - 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 193mHg 3E+3 7E+3 3E-6 1E-8 4E-5 4E-4  
 W, see 193mHg - 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 193mHg 6E+3 1E+4 5E-6 2E-8 8E-5 8E-4  
 W, see 193mHg - 9E+3 4E-6 1E-8 - -  
80 Mercury-199m2 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 193mHg 6E+4 1E+5 6E-5 2E-7 8E-4 8E-3  
 W, see 193mHg - 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 193mHg 2E+3 1E+3 5E-7 2E-9 3E-5 3E-4  
 W, see 193mHg - 1E+3 5E-7 2E-9 - -  
81 Thallium-194m2 D, all compounds 5E+4 2E+5 6E-5 2E-7 - -  
 St wall  
 (7E+4) - - - 1E-3 1E-2  
81 Thallium-1942 D, all compounds 3E+5 6E+5 2E-4 8E-7 - -  
 St wall  
 (3E+5) - - - 4E-3 4E-2

81 Thallium-1952 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-198m2 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  
81 Thallium-204 D, all compounds 2E+3 2E+3 9E-7 3E-9 2E-5 2E-4  
82 Lead-195m2 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-199² D, all compounds 2E+4 7E+4 3E-5 1E-7 3E-4 3E-3

Table I Table II Table III  
 Effluent Releases to  
 Occupational Values Concentrations Sewers

Col. 1 Col. 2 Col. 3 Col. 1 Col. 2  
 Oral Monthly  
 Ingestion Inhalation Average  
Atomic ALI ALI DAC Air Water Concentration  
No. Radionuclide Class (Ci) (Ci) (Ci/ml) (Ci/ml) (Ci/ml) (Ci/ml)

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 6E1 2E1 1E-10 - - -  
 Bone surf Bone surf  
 (1E+0) (4E-1) - 6E-13 1E-8 1E-7  
82 Lead-2112 D, all compounds 1E+4 6E+2 3E-7 9E-10 2E-4 2E-3  
82 Lead-212 D, all compounds 8E+1 3E+1 1E-8 5E-11 - -  
 Bone surf   
 (1E+2) - - - 2E-6 2E-5  
82 Lead-214² D, all compounds 9E+3 8E+2 3E-7 1E-9 1E-4 1E-3  
83 Bismuth-2002 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-2012 D, see 200Bi 1E+4 3E+4 1E-5 4E-8 2E-4 2E-3  
 W, see 200Bi - 4E+4 2E-5 5E-8 - -  
83 Bismuth-2022 D, see 200Bi 1E+4 4E+4 2E-5 6E-8 2E-4 2E-3  
 W, see 200Bi - 8E+4 3E-5 1E-7 - -  
83 Bismuth-203 D, see 200Bi 2E+3 7E+3 3E-6 9E-9 3E-5 3E-4  
 W, see 200Bi - 6E+3 3E-6 9E-9 - -  
83 Bismuth-205 D, see 200Bi 1E+3 3E+3 1E-6 3E-9 2E-5 2E-4  
 W, see 200Bi - 1E+3 5E-7 2E-9 - -  
83 Bismuth-206 D, see 200Bi 6E+2 1E+3 6E-7 2E-9 9E-6 9E-5  
 W, see 200Bi - 9E+2 4E-7 1E-9 - -  
83 Bismuth-207 D, see 200Bi 1E+3 2E+3 7E-7 2E-9 1E-5 1E-4  
 W, see 200Bi - 4E+2 1E-7 5E-10 - -  
83 Bismuth-210m D, see 200Bi 4E+1 5E+0 2E-9 - - -  
 Kidneys Kidneys  
 (6E+1) (6E+0) - 9E-12 8E-7 8E-6  
 W, see 200Bi - 7E-1 3E-10 9E-13 - -  
83 Bismuth-210 D, see 200Bi 8E+2 2E+2 1E-7 - 1E-5 1E-4  
 - Kidneys  
 - (4E+2) - 5E-10 - -  
 W, see 200Bi - 3E+1 1E-8 4E-11 - -  
83 Bismuth-2122 D, see 200Bi 5E+3 2E+2 1E-7 3E-10 7E-5 7E-4  
 W, see 200Bi - 3E+2 1E-7 4E-10 - -  
83 Bismuth-2132 D, see 200Bi 7E+3 3E+2 1E-7 4E-10 1E-4 1E-3  
 W, see 200Bi - 4E+2 1E-7 5E-10 - -  
83 Bismuth-2142 D, see 200Bi 2E+4 8E+2 3E-7 1E-9 - -  
 St wall   
 (2E+4) - - - 3E-4 3E-3  
 W, see 200Bi - 9E-2 4E-7 1E-9 - -  
84 Polonium-2032 D, all compounds except  
 those given for W 3E+4 6E+4 3E-5 9E-8 3E-4 3E-3  
 W, oxides, hydroxides,  
 and nitrates - 9E+4 4E-5 1E-7 - -  
84 Polonium-2052 D, see 203Po 2E+4 4E+4 2E-5 5E-8 3E-4 3E-3  
 W, see 203Po - 7E+4 3E-5 1E-7 - -  
84 Polonium-207 D, see 203Po 8E+3 3E+4 1E-5 3E-8 1E-4 1E-3  
 W, see 203Po - 3E+4 1E-5 4E-8 - -  
84 Polonium-210 D, see 203Po 3E+0 6E-1 3E-10 9E-13 4E-8 4E-7  
 W, see 203Po - 6E-1 3E-10 9E-13 - -  
85 Astatine-2072 D, halides 6E+3 3E+3 1E-6 4E-9 8E-5 8E-4  
 W - 2E+3 9E-7 3E-9 - -  
85 Astatine-211 D, halides 1E+2 8E+1 3E-8 1E-10 2E-6 2E-5  
 W - 5E+1 2E-8 8E-11 - -  
86 Radon-220 With daughters removed - 2E+4 7E-6 2E-8 - -  
 With daughters present - 2E+1 9E-9 3E-11 - -  
 (or 12 (or 1.0   
 WLM) WL)  
86 Radon-222 With daughters removed - 1E+4 4E-6 1E-8 - -  
 With daughters present - 1E+2 3E-8 1E-10 - -  
 (or 4 (or 0.33  
 WLM) WL)  
   
87 Francium-2222 D, all compounds 2E+3 5E+2 2E-7 6E-10 3E-5 3E-4  
87 Francium-2232 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

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

Table I Table II Table III  
 Effluent Releases to  
 Occupational Values Concentrations Sewers

Col. 1 Col. 2 Col. 3 Col. 1 Col. 2  
 Oral Monthly  
 Ingestion Inhalation Average  
Atomic ALI ALI DAC Air Water Concentration  
No. Radionuclide Class (Ci) (Ci) (Ci/ml) (Ci/ml) (Ci/ml) (Ci/ml)

88 Radium-226 W, all compounds 2E+0 6E-1 3E-10 9E-13 - -  
 Bone surf   
 (5E+0) - - - 6E-8 6E-7  
88 Radium-2272 W, all compounds 2E+4 1E+4 6E-6 - - -  
 Bone surf Bone surf  
 (2E+4) (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 3E+1 1E-8 - - -  
 LLI wall Bone surf  
 (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 224Ac 5E+1 3E-1 1E-10 - - -  
 LLI wall Bone surf  
 (5E+1) (5E-1) - 7E-13 7E-7 7E-6  
 W, see 224Ac - 6E-1 3E-10 9E-13 - -  
 Y, see 224Ac - 6E-1 3E-10 9E-13 - -  
89 Actinium-226 D, see 224Ac 1E+2 3E+0 1E-9 - - -  
 LLI wall Bone surf  
 (1E+2) (4E+0) - 5E-12 2E-6 2E-5  
 W, see 224Ac - 5E+0 2E-9 7E-12 - -  
 Y, see 224Ac - 5E+0 2E-9 6E-12 - -  
89 Actinium-227 D, see 224Ac 2E-1 4E-4 2E-13 - - -  
 Bone surf Bone surf  
 (4E-1) (8E-4) - 1E-15 5E-9 5E-8  
 W, see 224Ac - 2E-3 7E-13 - - -  
 Bone surf  
 - (3E-3) - 4E-15 - -  
 Y, see 224Ac - 4E-3 2E-12 6E-15 - -  
89 Actinium-228 D, see 224Ac 2E+3 9E+0 4E-9 - 3E-5 3E-4  
 Bone surf  
 - (2E+1) - 2E-11 - -  
 W, see 224Ac - 4E+1 2E-8 - - -  
 Bone surf  
 - (6E+1) - 8E-11 - -  
 Y, see 224Ac - 4E+1 2E-8 6E-11 - -  
90 Thorium-226² W, all compounds except  
 those given for Y 5E+3 2E+2 6E-8 2E-10 - -  
 St wall  
 (5E+3) - - - 7E-5 7E-4  
 Y, oxides and hydroxides - 1E+2 6E-8 2E-10 - -  
90 Thorium-227 W, see 226Th 1E+2 3E-1 1E-10 5E-13 2E-6 2E-5  
 Y, see 226Th - 3E-1 1E-10 5E-13 - -  
90 Thorium-228 W, see 226Th 6E+0 1E-2 4E-12 - - -  
 Bone surf Bone surf  
 (1E+1) (2E-2) - 3E-14 2E-7 2E-6  
 Y, see 226Th - 2E-2 7E-12 2E-14 - -  
90 Thorium-229 W, see 226Th 6E-1 9E-4 4E-13 - - -  
 Bone surf Bone surf  
 (1E+0) (2E-3) - 3E-15 2E-8 2E-7  
 Y, see 226Th - 2E-3 1E-12 - - -  
 Bone surf  
 - (3E-3) - 4E-15 - -  
90 Thorium-230 W, see 226Th 4E+0 6E-3 3E-12 - - -  
 Bone surf Bone surf  
 (9E+0) (2E-2) - 2E-14 1E-7 1E-6  
 Y, see 226Th - 2E-2 6E-12 - - -  
 Bone surf  
 - (2E-2) - 3E-14 - -  
90 Thorium-231 W, see 226Th 4E+3 6E+3 3E-6 9E-9 5E-5 5E-4  
 Y, see 226Th - 6E+3 3E-6 9E-9 - -  
90 Thorium-232 W, see 226Th 7E-1 1E-3 5E-13 - - -  
 Bone surf Bone surf  
 (2E+0) (3E-3) - 4E-15 3E-8 3E-7  
 Y, see 226Th - 3E-3 1E-12 - - -  
 Bone surf  
 - (4E-3) - 6E-15 - -  
90 Thorium-234 W, see 226Th 3E+2 2E+2 8E-8 3E-10 - -  
 LLI wall  
 (4E+2) - - - 5E-6 5E-5  
 Y, see 226Th - 2E+2 6E-8 2E-10 - -  
91 Protactinium-2272 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 - -

Table I Table II Table III  
 Effluent Releases to  
 Occupational Values Concentrations Sewers

Col. 1 Col. 2 Col. 3 Col. 1 Col. 2  
 Oral Monthly  
 Ingestion Inhalation Average  
Atomic ALI ALI DAC Air Water Concentration  
No. Radionuclide Class (Ci) (Ci) (Ci/ml) (Ci/ml) (Ci/ml) (Ci/ml)

91 Protactinium-228 W, see 227Pa 1E+3 1E+1 5E-9 - 2E-5 2E-4  
 Bone surf  
 - (2E+1) - 3E-11 - -  
 Y, see 227Pa - 1E+1 5E-9 2E-11 - -  
91 Protactinium-230 W, see 227Pa 6E+2 5E+0 2E-9 7E-12 - -  
 Bone surf   
 (9E+2) - - - 1E-5 1E-4  
 Y, see 227Pa - 4E+0 1E-9 5E-12 - -  
91 Protactinium-231 W, see 227Pa 2E-1 2E-3 6E-13 - - -  
 Bone surf Bone surf  
 (5E-1) (4E-3) - 6E-15 6E-9 6E-8  
 Y, see 227Pa - 4E-3 2E-12 - - -  
 Bone surf  
 - (6E-3) - 8E-15 - -  
91 Protactinium-232 W, see 227Pa 1E+3 2E+1 9E-9 - 2E-5 2E-4  
 Bone surf  
 - (6E+1) - 8E-11 - -  
 Y, see 227Pa - 6E+1 2E-8 - - -  
 Bone surf  
 - (7E+1) - 1E-10 - -  
91 Protactinium-233 W, see 227Pa 1E+3 7E+2 3E-7 1E-9 - -  
 LLI wall   
 (2E+3) - - - 2E-5 2E-4  
 Y, see 227Pa - 6E+2 2E-7 8E-10 - -  
91 Protactinium-234 W, see 227Pa 2E+3 8E+3 3E-6 1E-8 3E-5 3E-4  
 Y, see 227Pa - 7E+3 3E-6 9E-9 - -  
92 Uranium-230 D, UF, UOF, UO(NO) 4E+0 4E-1 2E-10 - - -  
 Bone surf Bone surf  
 (6E+0) (6E-1) - 8E-13 8E-8 8E-7  
 W, UO, UF, UCl - 4E-1 1E-10 5E-13 - -  
 Y, UO, UO - 3E-1 1E-10 4E-13 - -  
92 Uranium-231 D, see 230U 5E+3 8E+3 3E-6 1E-8 - -  
 LLI wall  
 (4E+3) - - - 6E-5 6E-4  
 W, see 230U - 6E+3 2E-6 8E-9 - -  
 Y, see 230U - 5E+3 2E-6 6E-9 - -  
92 Uranium-232 D, see 230U 2E+0 2E-1 9E-11 - - -  
 Bone surf Bone surf  
 (4E+0) (4E-1) - 6E-13 6E-8 6E-7  
 W, see 230U - 4E-1 2E-10 5E-13 - -  
 Y, see 230U - 8E-3 3E-12 1E-14 - -  
92 Uranium-233 D, see 230U 1E+1 1E+0 5E-10 - - -  
 Bone surf Bone surf  
 (2E+1) (2E+0) - 3E-12 3E-7 3E-6  
 W, see 230U - 7E-1 3E-10 1E-12 - -  
 Y, see 230U - 4E-2 2E-11 5E-14 - -  
92 Uranium-2343 D, see 230U 1E+1 1E+0 5E-10 - - -  
 Bone surf Bone surf  
 (2E+1) (2E+0) - 3E-12 3E-7 3E-6  
 W, see 230U - 7E-1 3E-10 1E-12 - -  
 Y, see 230U - 4E-2 2E-11 5E-14 - -  
92 Uranium-2353 D, see 230U 1E+1 1E+0 6E-10 - - -  
 Bone surf Bone surf  
 (2E+1) (2E+0) - 3E-12 3E-7 3E-6  
 W, see 230U - 8E-1 3E-10 1E-12 - -  
 Y, see 230U - 4E-2 2E-11 6E-14 - -  
92 Uranium-236 D, see 230U 1E+1 1E+0 5E-10 - - -  
 Bone surf Bone surf  
 (2E+1) (2E+0) - 3E-12 3E-7 3E-6  
 W, see 230U - 8E-1 3E-10 1E-12 - -  
 Y, see 230U - 4E-2 2E-11 6E-14 - -  
92 Uranium-237 D, see 230U 2E+3 3E+3 1E-6 4E-9 - -  
 LLI wall   
 (2E+3) - - - 3E-5 3E-4  
 W, see 230U - 2E+3 7E-7 2E-9 - -  
 Y, see 230U - 2E+3 6E-7 2E-9 - -  
92 Uranium-2383 D, see 230U 1E+1 1E+0 6E-10 - - -  
 Bone surf Bone surf  
 (2E+1) (2E+0) - 3E-12 3E-7 3E-6  
 W, see 230U - 8E-1 3E-10 1E-12 - -  
 Y, see 230U - 4E-2 2E-11 6E-14 - -  
92 Uranium-2392 D, see 230U 7E+4 2E+5 8E-5 3E-7 9E-4 9E-3  
 W, see 230U - 2E+5 7E-5 2E-7 - -  
 Y, see 230U - 2E+5 6E-5 2E-7 - -  
92 Uranium-240 D, see 230U 1E+3 4E+3 2E-6 5E-9 2E-5 2E-4  
 W, see 230U - 3E+3 1E-6 4E-9 - -  
 Y, see 230U - 2E+3 1E-6 3E-9 - -

Table I Table II Table III  
 Effluent Releases to  
 Occupational Values Concentrations Sewers

Col. 1 Col. 2 Col. 3 Col. 1 Col. 2  
 Oral Monthly  
 Ingestion Inhalation Average  
Atomic ALI ALI DAC Air Water Concentration  
No. Radionuclide Class (Ci) (Ci) (Ci/ml) (Ci/ml) (Ci/ml) (Ci/ml)

92 Uranium-natural3 D, see 230U 1E+1 1E+0 5E-10 - - -  
 Bone surf Bone surf  
 (2E+1) (2E+0) - 3E-12 3E-7 3E-6  
 W, see 230U - 8E-1 3E-10 9E-13 - -  
 Y, see 230U - 5E-2 2E-11 9E-14 - -  
93 Neptunium-2322 W, all compounds 1E+5 2E+3 7E-7 - 2E-3 2E-2  
 Bone surf  
 - (5E+2) - 6E-9 - -  
93 Neptunium-2332 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 8E+2 3E-7 - - -  
 LLI wall Bone surf  
 (2E+4) (1E+3) - 2E-9 3E-4 3E-3  
93 Neptunium-236 W, all compounds 3E+0 2E-2 9E-12 - - -  
 (1.15E+5 y) Bone surf Bone surf  
 (6E+0) (5E-2) - 8E-14 9E-8 9E-7  
93 Neptunium-236 W, all compounds 3E+3 3E+1 1E-8 - - -  
 (22.5 h) Bone surf Bone surf  
 (4E+3) (7E+1) - 1E-10 5E-5 5E-4  
93 Neptunium-237 W, all compounds 5E-1 4E-3 2E-12 - - -  
 Bone surf Bone surf  
 (1E+0) (1E-2) - 1E-14 2E-8 2E-7  
93 Neptunium-238 W, all compounds 1E+3 6E+1 3E-8 - 2E-5 2E-4  
 Bone surf  
 - (2E+2) - 2E-10 - -  
93 Neptunium-239 W, all compounds 2E+3 2E+3 9E-7 3E-9 - -  
 LLI wall   
 (2E+3) - - - 2E-5 2E-4  
93 Neptunium-2402 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-2352 W, see 234Pu 9E+5 3E+6 1E-3 4E-6 1E-2 1E-1  
 Y, see 234Pu - 3E+6 1E-3 3E-6 - -  
94 Plutonium-236 W, see 234Pu 2E+0 2E-2 8E-12 - - -  
 Bone surf Bone surf  
 (4E+0) (4E-2) - 5E-14 6E-8 6E-7  
 Y, see 234Pu - 4E-2 2E-11 6E-14 - -  
94 Plutonium-237 W, see 234Pu 1E+4 3E+3 1E-6 5E-9 2E-4 2E-3  
 Y, see 234Pu - 3E+3 1E-6 4E-9 - -  
94 Plutonium-238 W, see 234Pu 9E-1 7E-3 3E-12 - - -  
 Bone surf Bone surf  
 (2E+0) (1E-2) - 2E-14 2E-8 2E-7  
 Y, see 234Pu - 2E-2 8E-12 2E-14 - -  
94 Plutonium-239 W, see 234Pu 8E-1 6E-3 3E-12 - - -  
 Bone surf Bone surf  
 (1E+0) (1E-2) - 2E-14 2E-8 2E-7  
 Y, see 234Pu - 2E-2 7E-12 - - -  
 Bone surf  
 - (2E-2) - 2E-14 - -  
94 Plutonium-240 W, see 234Pu 8E-1 6E-3 3E-12 - - -  
 Bone surf Bone surf  
 (1E+0) (1E-2) - 2E-14 2E-8 2E-7  
 Y, see 234Pu - 2E-2 7E-12 - - -  
 Bone surf  
 - (2E-2) - 2E-14 - -  
94 Plutonium-241 W, see 234Pu 4E+1 3E-1 1E-10 - - -  
 Bone surf Bone surf  
 (7E+1) (6E-1) - 8E-13 1E-6 1E-5  
 Y, see 234Pu - 8E-1 3E-10 - - -  
 Bone surf  
 - (1E+0) - 1E-12 - -  
94 Plutonium-242 W, see 234Pu 8E-1 7E-3 3E-12 - - -  
 Bone surf Bone surf  
 (1E+0) (1E-2) - 2E-14 2E-8 2E-7  
 Y, see 234Pu - 2E-2 7E-12 - - -  
 Bone surf  
 - (2E-2) - 2E-14 - -  
94 Plutonium-243 W, see 234Pu 2E+4 4E+4 2E-5 5E-8 2E-4 2E-3  
 Y, see 234Pu - 4E+4 2E-5 5E-8 - -  
94 Plutonium-244 W, see 234Pu 8E-1 7E-3 3E-12 - - -  
 Bone surf Bone surf  
 (2E+0) (1E-2) - 2E-14 2E-8 2E-7  
 Y, see 234Pu - 2E-2 7E-12 - - -  
 Bone surf  
 - (2E-2) - 2E-14 - -  
94 Plutonium-245 W, see 234Pu 2E+3 5E+3 2E-6 6E-9 3E-5 3E-4  
 Y, see 234Pu - 4E+3 2E-6 6E-9 - -  
94 Plutonium-246 W, see 234Pu 4E+2 3E+2 1E-7 4E-10 - -  
 LLI wall   
 (4E+2) - - - 6E-6 6E-5  
 Y, see 234Pu - 3E+2 1E-7 4E-10 - -

Table I Table II Table III  
 Effluent Releases to  
 Occupational Values Concentrations Sewers

Col. 1 Col. 2 Col. 3 Col. 1 Col. 2  
 Oral Monthly  
 Ingestion Inhalation Average  
Atomic ALI ALI DAC Air Water Concentration  
No. Radionuclide Class (Ci) (Ci) (Ci/ml) (Ci/ml) (Ci/ml) (Ci/ml)

95 Americium-2372 W, all compounds 8E+4 3E+5 1E-4 4E-7 1E-3 1E-2  
95 Americium-2382 W, all compounds 4E+4 3E+3 1E-6 - 5E-4 5E-3  
 Bone surf  
 - (6E+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 Bone surf  
 (1E+0) (1E-2) - 2E-14 2E-8 2E-7  
95 Americium-242m W, all compounds 8E-1 6E-3 3E-12 - - -  
 Bone surf Bone surf  
 (1E+0) (1E-2) - 2E-14 2E-8 2E-7  
95 Americium-242 W, all compounds 4E+3 8E+1 4E-8 - 5E-5 5E-4  
 Bone surf  
 - (9E+1) - 1E-10 - -  
95 Americium-243 W, all compounds 8E-1 6E-3 3E-12 - - -  
 Bone surf Bone surf  
 (1E+0) (1E-2) - 2E-14 2E-8 2E-7  
95 Americium-244m2 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-246m2 W, all compounds 5E+4 2E+5 8E-5 3E-7 - -  
 St wall   
 (6E+4) - - - 8E-4 8E-3  
95 Americium-2462 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  
96 Curium-249² W, all compounds 5E+4 2E+4 7E-6 - 7E-4 7E-3  
 Bone surf  
 - (3E+4) - 4E-8 - -  
96 Curium-250 W, all compounds 4E-2 3E-4 1E-13 - - -  
 Bone surf Bone surf  
 (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 4E-3 2E-12 - - -  
 Bone surf Bone surf  
 (1E+0) (9E-3) - 1E-14 2E-8 2E-7  
97 Berkelium-249 W, all compounds 2E+2 2E+0 7E-10 - - -  
 Bone surf Bone surf  
 (5E+2) (4E+0) - 5E-12 6E-6 6E-5  
97 Berkelium-250 W, all compounds 9E+3 3E+2 1E-7 - 1E-4 1E-3  
 Bone surf  
 - (7E+2) - 1E-9 - -  
98 Californium-2442 W, all compounds except  
 those given for Y 3E+4 6E+2 2E-7 8E-10 - -  
 St wall  
 (3E+4) - - - 4E-4 4E-3  
 Y, oxides and hydroxides - 6E+2 2E-7 8E-10 - -

Table I Table II Table III  
 Effluent Releases to  
 Occupational Values Concentrations Sewers

Col. 1 Col. 2 Col. 3 Col. 1 Col. 2  
 Oral Monthly  
 Ingestion Inhalation Average  
Atomic ALI ALI DAC Air Water Concentration  
No. Radionuclide Class (Ci) (Ci) (Ci/ml) (Ci/ml) (Ci/ml) (Ci/ml)

98 Californium-246 W, see 244Cf 4E+2 9E+0 4E-9 1E-11 5E-6 5E-5  
 Y, see 244Cf - 9E+0 4E-9 1E-11 - -  
98 Californium-248 W, see 244Cf 8E+0 6E-2 3E-11 - - -  
 Bone surf Bone surf  
 (2E+1) (1E-1) - 2E-13 2E-7 2E-6  
 Y, see 244Cf - 1E-1 4E-11 1E-13 - -  
98 Californium-249 W, see 244Cf 5E-1 4E-3 2E-12 - - -  
 Bone surf Bone surf  
 (1E+0) (9E-3) - 1E-14 2E-8 2E-7  
 Y, see 244Cf - 1E-2 4E-12 - - -  
 Bone surf  
 - (1E-2) - 2E-14 - -  
98 Californium-250 W, see 244Cf 1E+0 9E-3 4E-12 - - -  
 Bone surf Bone surf  
 (2E+0) (2E-2) - 3E-14 3E-8 3E-7  
 Y, see 244Cf - 3E-2 1E-11 4E-14 - -  
98 Californium-251 W, see 244Cf 5E-1 4E-3 2E-12 - - -  
 Bone surf Bone surf  
 (1E+0) (9E-3) - 1E-14 2E-8 2E-7  
 Y, see 244Cf - 1E-2 4E-12 - - -  
 Bone surf  
 - (1E-2) - 2E-14 - -  
98 Californium-252 W, see 244Cf 2E+0 2E-2 8E-12 - - -  
 Bone surf Bone surf  
 (5E+0) (4E-2) - 5E-14 7E-8 7E-7  
 Y, see 244Cf - 3E-2 1E-11 5E-14 - -  
98 Californium-253 W, see 244Cf 2E+2 2E+0 8E-10 3E-12 - -  
 Bone surf   
 (4E+2) - - - 5E-6 5E-5  
 Y, see 244Cf - 2E+0 7E-10 2E-12 - -  
98 Californium-254 W, see 244Cf 2E+0 2E-2 9E-12 3E-14 3E-8 3E-7  
 Y, see 244Cf - 2E-2 7E-12 2E-14 - -  
99 Einsteinium-250 W, all compounds 4E+4 5E+2 2E-7 - 6E-4 6E-3  
 Bone surf  
 - (1E+3) - 2E-9 - -  
99 Einsteinium-251 W, all compounds 7E+3 9E+2 4E-7 - 1E-4 1E-3  
 Bone surf  
 - (1E+3) - 2E-9 - -  
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 - -  
 LLI wall   
 (3E+2) - - - 4E-6 4E-5  
99 Einsteinium-254 W, all compounds 8E+0 7E-2 3E-11 - - -  
 Bone surf Bone surf  
 (2E+1) (1E-1) - 2E-13 2E-7 2E-6  
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 2E-1 7E-11 - - -  
 Bone surf Bone surf  
 (4E+1) (2E-1) - 3E-13 5E-7 5E-6  
101 Mendelevium-257 W, all compounds 7E+3 8E+1 4E-8 - 1E-4 1E-3  
 Bone surf  
 - (9E+1) - 1E-10 - -  
101 Mendelevium-258 W, all compounds 3E+1 2E-1 1E-10 - - -  
 Bone surf Bone surf  
 (5E+1) (3E-1) - 5E-13 6E-7 6E-6  
-Any single radionuclide not listed  
above with decay mode other than  
alpha emission or spontaneous fis-  
sion and with radioactive half-  
life less than 2 hours Submersion1 - 2E+2 1E-7 1E-9 - -  
-Any single radionuclide not listed  
above with decay mode other than  
alpha emission or spontaneous fis-  
sion and with radioactive half-  
life greater than 2 hours . . . . - 2E-1 1E-10 1E-12 1E-8 1E-7  
-Any single radionuclide not listed  
above that decays by alpha emission  
or spontaneous fission, or any mix-  
ture 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:**

1. Submersion means that values given are for submersion in a hemispherical semi-infinite cloud of airborne material.

2. These radionuclides have radiological half-lives of fewer than two 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 Ci/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 D.1203.)

3 For soluble mixtures of U-238, U-234, and U-235 in air, chemical toxicity may be the limiting factor (see 20.1201(e)). 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 curies/gram U U-depleted

SA = [0.4 + 0.38 (enrichment) + 0.0034 (enrichment)2] E-6 , enrichment > 0.72

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

**NOTES:**

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

Table I Table II Table III  
 Effluent Releases to  
 Occupational Values Concentrations Sewers

Col. 1 Col. 2 Col. 3 Col. 1 Col. 2  
 Oral Monthly  
 Ingestion Inhalation Average  
Atomic ALI ALI DAC Air Water Concentration  
No. Radionuclide Class (Ci) (Ci) (Ci/ml) (Ci/ml) (Ci/ml) (Ci/ml)

If it is known that Ac-227-D and Cm-250-W are  
not present - 7E-4 3E-13 - - -

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 - - -

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 - - -

Table I Table II Table III  
 Effluent Releases to  
 Occupational Values Concentrations Sewers

Col. 1 Col. 2 Col. 3 Col. 1 Col. 2  
 Oral Monthly  
 Ingestion Inhalation Average  
Atomic ALI ALI DAC Air Water Concentration  
No. Radionuclide Class (Ci) (Ci) (Ci/ml) (Ci/ml) (Ci/ml) (Ci/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

**NOTES:**

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 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 CA, CB, and CC, and if the applicable DACs are DACA, DACB, and DACC, respectively, then the concentrations shall be limited so that the following relationship exists:

CA + CB + CC ≤ 1

DACA DACB DACC

**APPENDIX C.**

**QUANTITIES1 OF LICENSED OR REGISTERED MATERIAL REQUIRING LABELING**

Radionuclide Quantity Radionuclide Quantity  
 (μCi)\* (μCi)\*

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

\* To convert μCi to kBq, multiply the μCi value by 37.

**QUANTITIES1 OF LICENSED OR REGISTERED MATERIAL REQUIRING LABELING**

Radionuclide Quantity Radionuclide Quantity  
 (μCi)\* (μCi)\*

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

\* To convert μCi to kBq, multiply the μCi value by 37.

**QUANTITIES1 OF LICENSED OR REGISTERED MATERIAL REQUIRING LABELING**

Radionuclide Quantity Radionuclide Quantity  
 (μCi)\* (μCi)\*

Niobium-89m (66 min) 1,000 Palladium-101 1,000  
Niobium-89 (122 min) 1,000 Palladium-103 100  
Niobium-90 100 Palladium-107 10  
Niobium-93m 10 Palladium-109 100  
Niobium-94 1 Silver-102 1,000  
Niobium-95m 100 Silver-103 1,000  
Niobium-95 100 Silver-104m 1,000  
Niobium-96 100 Silver-104 1,000  
Niobium-97 1,000 Silver-105 100  
Niobium-98 1,000 Silver-106m 100  
Molybdenum-90 100 Silver-106 1,000  
Molybdenum-93m 100 Silver-108m 1  
Molybdenum-93 10 Silver-110m 10  
Molybdenum-99 100 Silver-111 100  
Molybdenum-101 1,000 Silver-112 100  
Technetium-93m 1,000 Silver-115 1,000  
Technetium-93 1,000 Cadmium-104 1,000  
Technetium-94m 1,000 Cadmium-107 1,000  
Technetium-94 1,000 Cadmium-109 1  
Technetium-96m 1,000 Cadmium-113m 0.1  
Technetium-96 100 Cadmium-113 100  
Technetium-97m 100 Cadmium-115m 10  
Technetium-97 1,000 Cadmium-115 100  
Technetium-98 10 Cadmium-117m 1,000  
Technetium-99m 1,000 Cadmium-117 1,000  
Technetium-99 100 Indium-109 1,000  
Technetium-101 1,000 Indium-110m(69.1m) 1,000  
Technetium-104 1,000 Indium-110 (4.9h) 1,000  
Ruthenium-94 1,000 Indium-111 100  
Ruthenium-97 1,000 Indium-112 1,000  
Ruthenium-103 100 Indium-113m 1,000  
Ruthenium-105 1,000 Indium-114m 10  
Ruthenium-106 1 Indium-115m 1,000  
Rhodium-99m 1,000 Indium-115 100  
Rhodium-99 100 Indium-116m 1,000  
Rhodium-100 100 Indium-117m 1,000  
Rhodium-101m 1,000 Indium-117 1,000  
Rhodium-101 10 Indium-119m 1,000  
Rhodium-102m 10 Tin-110 100  
Rhodium-102 10 Tin-111 1,000  
Rhodium-103m 1,000 Tin-113 100  
Rhodium-105 100 Tin-117m 100  
Rhodium-106m 1,000 Tin-119m 100  
Rhodium-107 1,000 Tin-121m 100  
Palladium-100 100 Tin-121 1,000

\* To convert μCi to kBq, multiply the μCi value by 37.

**QUANTITIES1 OF LICENSED OR REGISTERED MATERIAL REQUIRING LABELING**

Radionuclide Quantity Radionuclide Quantity  
 (μCi)\* (μCi)\*

Tin-123m 1,000 Iodine-120m 1,000  
Tin-123 10 Iodine-120 100  
Tin-125 10 Iodine-121 1,000  
Tin-126 10 Iodine-123 100  
Tin-127 1,000 Iodine-124 10  
Tin-128 1,000 Iodine-125 1  
Antimony-115 1,000 Iodine-126 1  
Antimony-116m 1,000 Iodine-128 1,000  
Antimony-116 1,000 Iodine-129 1  
Antimony-117 1,000 Iodine-130 10  
Antimony-118m 1,000 Iodine-131 1  
Antimony-119 1,000 Iodine-132m 100  
Antimony-120 (16m) 1,000 Iodine-132 100  
Antimony-120 (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 (10.4m) 1,000 Xenon-127 1,000  
Antimony-128 (9.O1h) 100 Xenon-129m 1,000  
Antimony-129 100 Xenon-131m 1,000  
Antimony-130 1,000 Xenon-133m 1,000  
Antimony-131 1,000 Xenon-133 1,000  
Tellurium-116 1,000 Xenon-135m 1,000  
Tellurium-121m 10 Xenon-135 1,000  
Tellurium-121 100 Xenon-138 1,000  
Tellurium-123m 10 Cesium-125 1,000  
Tellurium-123 100 Cesium-127 1,000  
Tellurium-125m 10 Cesium-129 1,000  
Tellurium-127m 10 Cesium-130 1,000  
Tellurium-127 1,000 Cesium-131 1,000  
Tellurium-129m 10 Cesium-132 100  
Tellurium-129 1,000 Cesium-134m 1,000  
Tellurium-131m 10 Cesium-134 10  
Tellurium-131 100 Cesium-135m 1,000  
Tellurium-132 10 Cesium-135 100  
Tellurium-133m 100 Cesium-136 10  
Tellurium-133 1,000 Cesium-137 10  
Tellurium-134 1,000 Cesium-138 1,000

\* To convert μCi to kBq, multiply the μCi value by 37.

**QUANTITIES1 OF LICENSED OR REGISTERED MATERIAL REQUIRING LABELING**

Radionuclide Quantity Radionuclide Quantity  
 (μCi)\* (μCi)\*

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 (12.62h) 100  
Cerium-144 1 Europium-150 (34.2y) 1   
Praseodymium-136 1,000 Europium-152m 100  
Praseodymium-137 1,000 Europium-152 1   
Praseodymium-138m 1,000 Europium-154 1  
Praseodymium-139 1,000 Europium-155 10  
Praseodymium-142m 1,000 Europium-156 100  
Praseodymium-142 100 Europium-157 100  
Praseodymium-143 100 Europium-158 1,000  
Praseodymium-144 1,000 Gadolinium-145 1,000  
Praseodymium-145 100 Gadolinium-146 10  
Praseodymium-147 1,000 Gadolinium-147 100  
Neodymium-136 1,000 Gadolinium-148 0.001  
Neodymium-138 100 Gadolinium-149 100  
Neodymium-139m 1,000 Gadolinium-151 10  
Neodymium-139 1,000 Gadolinium-152 100  
Neodymium-141 1,000 Gadolinium-153 10  
Neodymium-147 100 Gadolinium-159 100  
Neodymium-149 1,000   
Neodymium-151 1,000

\* To convert μCi to kBq, multiply the μCi value by 37.

**QUANTITIES1 OF LICENSED OR REGISTERED MATERIAL REQUIRING LABELING**

Radionuclide Quantity Radionuclide Quantity  
 (μCi)\* (μCi)\*

Terbium-147 1,000 Ytterbium-167 1,000  
Terbium-149 100 Ytterbium-169 100  
Terbium-150 1,000 Ytterbium-175 100  
Terbium-151 100 Ytterbium-177 1,000  
Terbium-153 1,000 Ytterbium-178 1,000  
Terbium-154 100 Lutetium-169 100  
Terbium-155 1,000 Lutetium-170 100  
Terbium-156m (5.Oh) 1,000 Lutetium-171 100  
Terbium-156m (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  
Ytterbium-162 1,000 Tantalum-182 10  
Ytterbium-166 100 Tantalum-183 100  
 Tantalum-184 100  
 Tantalum-185 1,000

\* To convert μCi to kBq, multiply the μCi value by 37.

**QUANTITIES1 OF LICENSED OR REGISTERED MATERIAL REQUIRING LABELING**

Radionuclide Quantity Radionuclide Quantity  
 (μCi)\* (μCi)\*

Tantalum-186 1,000 Iridium-195m 1,000  
Tungsten-176 1,000 Iridium-195 1,000  
Tungsten-177 1,000 Platinum-186 1,000  
Tungsten-178 1,000 Platinum-188 100  
Tungsten-179 1,000 Platinum-189 1,000  
Tungsten-181 1,000 Platinum-191 100  
Tungsten-185 100 Platinum-193m 100  
Tungsten-187 100 Platinum-193 1,000  
Tungsten-188 10 Platinum-195m 100  
Rhenium-177 1,000 Platinum-197m 1,000  
Rhenium-178 1,000 Platinum-197 100  
Rhenium-181 1,000 Platinum-199 1,000  
Rhenium-182 (12.7h) 1,000 Platinum-200 100  
Rhenium-182 (64.Oh) 100 Gold-193 1,000  
Rhenium-184m 10 Gold-194 100  
Rhenium-184 100 Gold-195 10  
Rhenium-186m 10 Gold-198m 100  
Rhenium-186 100 Gold-198 100  
Rhenium-187 1,000 Gold-199 100  
Rhenium-188m 1,000 Gold-200m 100  
Rhenium-188 100 Gold-200 1,000  
Rhenium-189 100 Gold-201 1,000  
Osmium-180 1,000 Mercury-193m 100  
Osmium-181 1,000 Mercury-193 1,000  
Osmium-182 100 Mercury-194 1  
Osmium-185 100 Mercury-195m 100  
Osmium-189m 1,000 Mercury-195 1,000  
Osmium-191m 1,000 Mercury-197m 100   
Osmium-191 100 Mercury-197 1,000  
Osmium-193 100 Mercury-199m 1,000   
Osmium-194 1 Mercury-203 100  
Iridium-182 1,000 Thallium-194m 1,000  
Iridium-184 1,000 Thallium-194 1,000  
Iridium-185 1,000 Thallium-195 1,000   
Iridium-186 100 Thallium-197 1,000  
Iridium-187 1,000 Thallium-198m 1,000   
Iridium-188 100 Thallium-198 1,000  
Iridium-189 100 Thallium-199 1,000  
Iridium-190m 1,000 Thallium-200 1,000  
Iridium-190 100 Thallium-201 1,000   
Iridium-192 (73.8d) 1 Thallium-202 100  
Iridium-192m (1.4m) 10 Thallium-204 100  
Iridium-194m 10 Lead-195m 1,000  
Iridium-194 100 Lead-198 1,000

\* To convert μCi to kBq, multiply the μCi value by 37.

**QUANTITIES1 OF LICENSED OR REGISTERED MATERIAL REQUIRING LABELING**

Radionuclide Quantity Radionuclide Quantity  
 (μCi)\* (μCi)\*

Lead-199 1,000 Thorium-226 10  
Lead-200 100 Thorium-227 0.01  
Lead-201 1,000 Thorium-228 0.001  
Lead-202m 1,000 Thorium-229 0.001  
Lead-202 10 Thorium-230 0.001  
Lead-203 1,000 Thorium-231 100  
Lead-205 100 Thorium-232 100  
Lead-209 1,000 Thorium-234 10  
Lead-210 0.01 Thorium-natural 100  
Lead-211 100 Protactinium-227 10  
Lead-212 1 Protactinium-228 1  
Lead-214 100 Protactinium-230 0.1  
Bismuth-200 1,000 Protactinium-231 0.001  
Bismuth-201 1,000 Protactinium-232 1  
Bismuth-202 1,000 Protactinium-233 100  
Bismuth-203 100 Protactinium-234 100  
Bismuth-205 100 Uranium-230 0.01  
Bismuth-206 100 Uranium-231 100  
Bismuth-207 10 Uranium-232 0.001  
Bismuth-210m 0.1 Uranium-233 0.001  
Bismuth-210 1 Uranium-234 0.001  
Bismuth-212 10 Uranium-235 0.001  
Bismuth-213 10 Uranium-236 0.001  
Bismuth-214 100 Uranium-237 100  
Polonium-203 1,000 Uranium-238 100  
Polonium-205 1,000 Uranium-239 1,000  
Polonium-207 1,000 Uranium-240 100  
Polonium-210 0.1 Uranium-natural 100  
Astatine-207 100 Neptunium-232 100  
Astatine-211 10 Neptunium-233 1,000   
Radon-220 1 Neptunium-234 100  
Radon-222 1 Neptunium-235 100  
Francium-222 100 Neptunium-236 (1.15E+5) 0.001  
Francium-223 100 Neptunium-236 (22.5h) 1  
Radium-223 0.1 Neptunium-237 0.001  
Radium-224 0.1 Neptunium-238 10   
Radium-225 0.1 Neptunium-239 100   
Radium-226 0.1 Neptunium-240 1,000   
Radium-227 1,000 Plutonium-234 10   
Radium-228 0.1 Plutonium-235 1,000   
Actinium-224 1 Plutonium-236 0.001  
Actinium-225 0.01 Plutonium-237 100   
Actinium-226 0.1   
Actinium-227 0.001   
Actinium-228 1

\* To convert μCi to kBq, multiply the μCi value by 37.

**QUANTITIES1 OF LICENSED OR REGISTERED MATERIAL REQUIRING LABELING**

Radionuclide Quantity Radionuclide Quantity  
 (μCi)\* (μCi)\*

Plutonium-238 0.001 Curium-247 0.001  
Plutonium-239 0.001 Curium-248 0.001  
Plutonium-240 0.001 Curium-249 1,000  
Plutonium-241 0.01 Berkelium-245 100  
Plutonium-242 0.001 Berkelium-246 100  
Plutonium-243 1,000 Berkelium-247 0.001  
Plutonium-244 0.001 Berkelium-249 0.1  
Plutonium-245 100 Berkelium-250 10  
Americium-237 1,000 Californium-244 100  
Americium-238 100 Californium-246 1  
Americium-239 1,000 Californium-248 0.01  
Americium-240 100 Californium-249 0.001  
Americium-241 0.001 Californium-250 0.001  
Americium-242m 0.001 Californium-251 0.001  
Americium-242 10 Californium-252 0.001  
Americium-243 0.001 Californium-253 0.1  
Americium-244m 100 Californium-254 0.001  
Americium-244 10 Einsteinium-250 100  
Americium-245 1,000 Einsteinium-251 100  
Americium-246m 1,000 Einsteinium-253 0.1  
Americium-246 1,000 Einsteinium-254m 1  
Curium-238 100 Einsteinium-254 0.01  
Curium-240 0.1 Fermium-252 1   
Curium-241 1 Fermium-253 1   
Curium-242 0.01 Fermium-254 10  
Curium-243 0.001 Fermium-255 1  
Curium-244 0.001 Fermium-257 0.01  
Curium-245 0.001 Mendelevium-257 10  
Curium-246 0.001 Mendelevium-258 0.01  
  
Any alpha-emitting Any radionuclide  
radionuclide not other than alpha-  
listed above or emitting radionuclides  
mixtures of alpha not listed above, or  
emitters of unknown mixtures of beta  
composition 0.001 emitters of unknown  
 composition 0.01

NOTE: For purposes of D.1902(e), D.1905(a), and D.2201(a) 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.

1 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 Part D, rounding to the nearest factor of 10, and constraining the values listed between 37 Bq and 37 MBq (0.001 and 1,000 μCi). Values of 3.7 MBq (100 μCi) have been assigned for radionuclides having a radioactive half- life in excess of E+9 years, except rhenium, 37 MBq (1,000 μCi), to take into account their low specific activity.

**APPENDIX D.**

**Requirements for Transfers of Low-Level Radioactive Waste Intended for Disposal at**

**Licensed Land Disposal Facilities and Manifests**

**I. Manifest**

A. 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 Agency Forms (or other equivalent NRC, Licensing State or Agreement State approved forms) HHE-846 (Uniform Low-Level Radioactive Waste Manifest (Shipping Paper)) and HHE-847 (Uniform Low-Level Radioactive Waste Manifest (Container and Waste Description)) and, if necessary, on an applicable Agency Form HHE-848 (Uniform Low-Level Radioactive Waste Manifest (Manifest Index and Regional Compact Tabulation)). Agency Forms HHE-846 and HHE-846A must be completed and must physically accompany the pertinent low-level waste shipment. Upon agreement between shipper and consignee, Agency Forms HHE-847, HHE-847A, HHE-848 and HHE-848A 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 Agency to comply with the manifesting requirements of this Part when they ship:

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

2. LLW that is being returned to the licensee who is the waste generator or generator, as defined in this part; or

3. Radioactively contaminated material to a waste processor that becomes the processor's residual waste.

B. 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.

C. Agency Forms HHE-846, HHE-846A, HHE-847, HHE-847A, HHE-848 and HHE-848A, and the accompanying instructions, in hard copy, may be obtained from the Maine Radiation Control Program, Maine Center for Disease Control and Prevention, Department of Health and Human Services, 11 State House Station, Augusta, Maine 04333-0011.

D. This Appendix includes information requirements of the U.S. 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 Appendix.

E. As used in this Appendix, the following definitions apply:

1. **Agency Forms HHE-846, HHE-846A, HHE-847, HHE-847A, HHE-848 and HHE-848A** are official Agency Forms referenced in this Appendix. Licensees need not use originals of these Agency 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, Agency Forms HHE-847 (and HHE-847A) and Agency Forms HHE-848 (and HHE-848A) 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.

2. **Chemical description** means a description of the principal chemical characteristics of a low-level radioactive waste.

3. **Computer-readable medium** means that the regulatory Agency's computer can transfer the information from the medium into its memory.

4. **Consignee** means the designated receiver of the shipment of low-level radioactive waste.

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

6. **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.

7. **EPA identification number** means the number received by a transporter following application to the Administrator of EPA as required by 40 CFR Part 263.

8. **Generator** means a licensee operating under a Commission or Agreement State license who:

(a) Is a waste generator as defined in this part, or

(b) 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).

9. **High integrity container** (HIC) means a container commonly designed to meet the structural stability requirements of section V of this Appendix, and to meet Department of Transportation requirements for a Type A package.

10. **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 rule, a geologic repository is not considered a land disposal facility.

11. **Package** means the assembly of components necessary to ensure compliance with the packaging requirements of DOT regulations, together with its radioactive contents, as presented for transport.

12. **Physical description** means the items called for on Agency Form HHE-847 to describe a low-level radioactive waste.

13. **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.

14. **Shipper** means the licensed entity (i.e., the waste generator, waste collector, or waste processor) that 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.

15. **Shipping paper** means Agency Form HHE-846 and, if required, Agency Form HHE-846A, which includes the information, required by DOT in 49 CFR Part 172.

16. **Uniform Low-Level Radioactive Waste Manifest** or uniform manifest means the combination of Agency Forms HHE-846, HHE-847, and, if necessary, HHE-848, and their respective continuation sheets as needed, or equivalent.

17. **Waste collector** means an entity, operating under a Commission or Agreement State 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.

18. **Waste description** means the physical, chemical and radiological description of a low-level radioactive waste as called for on Agency Form HHE-847.

19. **Waste generator** means an entity, operating under a Commission or Agreement State license, that

(a) Possesses any material or component that contains radioactivity or is radioactively contaminated for which the licensee foresees no further use, and

(b) 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.

20. **Waste processor** means an entity, operating under a Commission or Agreement State license, the principal purpose of which 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.

21. **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).

**II. Information requirements**

A. General Information: The shipper of the radioactive waste, shall provide the following information on the uniform manifest:

1. The name, facility 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% chelating agent by weight, plus the identity of the principal chelating agent;

8. The approximate volume of waste within a container;

9. The absorbing 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 on 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 section V of this Appendix. Waste not meeting the structural stability requirements of section VI.B. of this Appendix 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% 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 section V. of this Appendix. Waste not meeting the structural stability requirements of section VI.B. of this Appendix 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. Multi-generator 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 part). 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 on 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% chelating agent by weight, plus the identity of the principal chelating agent;

(d) The absorbing 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 section VI.B. of this Appendix; 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.

**III. 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 Department of Transportation and the Agency. A collector in signing the certification is certifying that nothing has been done to the collected waste, which would invalidate the waste generator's certification.

**IV. Control and tracking:**

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

1. Prepare all wastes so that the waste is classified according to section V. of this Appendix and meets the waste characteristics requirements in section VI. of this Appendix;

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 then Class C waste, in accordance with section V. of this Appendix;

3. Conduct a quality assurance program to assure compliance with sections V. and VI. of this Appendix (the program must include management evaluation of audits);

4. Prepare the Agency 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

(a) receipt of the manifest precedes the LLW shipment or

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

6. Include Agency Form HHE-846 (and Agency Form HHE-846A, if required) with the shipment regardless of the option chosen in paragraph A.5 of this section;

7. Receive acknowledgement of the receipt of the shipment in the form of a signed copy of Agency Form HHE-846;

8. Retain a copy of or electronically store the Uniform Low-Level Radioactive Waste Manifest and documentation of acknowledgement of receipt as the record of transfer of licensed material as required by this rule; and

9. For any shipments or any part of a shipment for which acknowledgement of receipt has not been received within the times set forth in this 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 Agency Form HHE-846;

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:

(a) Receipt of the manifest precedes the LLW shipment or

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

4. Include Agency Form HHE-846 (and Agency Form HHE-846A, if required) with the shipment regardless of the option chosen in paragraph B.3 of this section;

5. Receive acknowledgement of the receipt of the shipment in the form of a signed copy of Agency Form HHE-846;

6. Retain a copy of or electronically store the Uniform Low-Level Radioactive Waste Manifest and documentation of acknowledgement of receipt as the record of transfer of licensed material as required by this rule;

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

8. Notify the shipper and the 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 cancelled.

C. Any licensed waste processor that 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 Agency Form HHE-846;

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 I.E. of this Appendix;

3. Prepare all wastes so that the waste is classified according to section V. of this Appendix and meets the waste characteristics requirements in section VI. of this Appendix;

4. Label each package of waste to identify whether it is Class A waste, Class B waste, or Class C waste, in accordance with sections V. and VI. of this Appendix;

5. Conduct a quality assurance program to assure compliance with sections V. and VI. of this Appendix (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:

(a) Receipt of the manifest precedes the LLW shipment or

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

7. Include Agency Forms HHE-846 (and Agency Forms HHE-846A, if required) with the shipment regardless of the option chosen in paragraph C.6 of this section;

8. Receive acknowledgement of the receipt of the shipment in the form of a signed copy of Agency Forms HHE-846;

9. Retain a copy of or electronically store the Uniform Low-Level Radioactive Waste Manifest and documentation of acknowledgement of receipt as the record of transfer of licensed material as required by this rule;

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

11. Notify the shipper and the 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 cancelled.

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 Agency Forms HHE-846 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 this Appendix until the Agency terminates the license; and

3. Notify the shipper and the 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 cancelled.

E. Any shipment or part of a shipment for which acknowledgement is not received within the times set forth in this section must:

1. Be investigated by the shipper if the shipper has not received notification 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 the Agency. Each licensee who conducts a trace investigation shall file a written report with the Agency within two weeks of completion of the investigation.

**V. Classification of waste**

A. Classification of waste for near surface disposal.

1. 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) the potential hazard of which 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.

2. Classes of waste.

(a) 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 VI.A. of this Appendix. If Class A waste also meets the stability requirements set forth in VI.B. of this Appendix, it is not necessary to segregate the waste for disposal.

(b) 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 VI of this Appendix.

(c) 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 VI of this Appendix.

(d) Waste that is not generally acceptable for near-surface disposal is waste for which form and disposal methods must be different, and in general more stringent, than those specified for Class C waste. In the absence of specific requirements in this part, such waste must be disposed of in a geologic repository as defined in 10 CFR Part 60 unless proposals for disposal of such waste in a disposal site licensed pursuant to 10 CFR Part 61 are approved by the Nuclear Regulatory Commission.

3. Classification determined by long-lived radionuclides. If radioactive waste contains only radionuclides listed in Table 1, classification shall be determined as follows:

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

(b) If the concentration exceeds 0.1 times the value in Table 1 but does not exceed the value in Table 1, the waste is Class C.

(c) If the concentration exceeds the value in Table 1, the waste is not generally acceptable for near-surface disposal.

(d) For wastes containing mixtures of radionuclides listed in Table 1, the total concentration shall be determined by the sum of fractions.

|  |  |
| --- | --- |
| **Table 1** | |
| **Radionuclide** | **Concentration curies per cubic meter** |
| 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 nuclides with half-life greater than 5 years | 1001 |
| Pu-241 | 3,5001 |
| Cm-242 | 20,0001 |

1 Units are nanocuries per gram.

4. Classification determined by short-lived radionuclides. If radioactive waste does not contain any of the radionuclides listed in Table 1, classification shall be determined based on the concentrations shown in Table 2. However, as specified in paragraph A.6. of this section, if radioactive waste does not contain any nuclides listed in either Table 1 or 2, it is Class A.

(a) If the concentration does not exceed the value in Column 1, the waste is Class A.

(b) If the concentration exceeds the value in Column 1, but does not exceed the value in Column 2, the waste is Class B.

(c) If the concentration exceeds the value in Column 2, but does not exceed the value in Column 3, the waste is Class C.

(d) If the concentration exceeds the value in Column 3, the waste is not generally acceptable for near-surface disposal.

(e) For wastes containing mixtures of the nuclides listed in Table 2, the total concentration shall be determined by the sum of fractions rule

|  |  |  |  |
| --- | --- | --- | --- |
| ****Table 2**** | | | |
| **Radionuclide** | **Concentration, curies per cubic meter** | | |
| **Col. 1** | **Col. 2** | **Col. 3** |
| Total of all nuclides with less than 5 year half-life | 700 | (1) | (1) |
| H-3 | 40 | (1) | (1) |
| Co-60 | 700 | (1) | (1) |
| 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 |

1 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 nuclides in Table 2 determine the waste to the Class C independent of these nuclides.

5. Classification determined by both long- and short-lived radionuclides. If radioactive waste contains a mixture of radionuclides, some of which are listed in Table 1, and some of which are listed in Table 2, classification shall be determined as follows:

(a) If the concentration of a nuclide listed in Table 1 does not exceed 0.1 times the value listed in Table 1, the class shall be that determined by the concentration of nuclides listed in Table 2.

(b) If the concentration of a nuclide listed in Table 1 exceeds 0.1 times the value listed in Table 1 but does not exceed the value in Table 1, the waste shall be Class C, provided the concentration of nuclides listed in Table 2 does not exceed the value shown in Column 3 of Table 2.

6. Classification of wastes with radio--0uclides other than those listed in Tables 1 and 2. If radioactive waste does not contain any nuclides listed in either Table 1 or 2, it is Class A.

7. 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 nuclide'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 50 Ci/m3. and Cs-137 in a concentration of 22 Ci/m3. Since the concentrations both exceed the values in Column 1, Table 2, 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.

8. 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 nanocuries per gram.

**VI. Waste characteristics.**

A. The following requirements are minimum requirements for all classes of waste and are intended to facilitate handling at the disposal site and provide protection of health and safety of personnel at the disposal site.

1. Waste must not be packaged for disposal in cardboard or fiberboard boxes.

2. Liquid waste must be solidified or packaged in sufficient absorbent material to absorb twice the volume of the liquid.

3. Solid waste containing liquid shall contain as little free standing and noncorrosive liquid as is reasonably achievable, but in no case shall the liquid exceed 1 percent of the volume.

4. Waste must not be readily capable of detonation or of explosive decomposition or reaction at normal pressures and temperatures, or of explosive reaction with water.

5. Waste must 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 paragraph A.7. of this section.

6. Waste must not be pyrophoric. Pyrophoric materials contained in waste shall be treated, prepared, and packaged to be nonflammable.

7. Waste in a gaseous form must be packaged at a pressure that does not exceed 1.5 atmospheres at 20º C. Total activity must not exceed 100 curies per container.

8. Waste containing hazardous, biological, pathogenic, or infectious material must be treated to reduce to the maximum extent practicable the potential hazard from the non-radiological materials.

B. The requirements in this section are intended to provide stability of the waste. Stability is intended to ensure that the waste does not structurally 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 must 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 VI.A.2 and 3, liquid wastes, or wastes containing liquid, must be converted into a form that contains as little free standing 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 must be reduced to the extent practicable.

**VII. Labeling.** Each package of waste must be clearly labeled to identify whether it is Class A waste, Class B waste, or Class C waste, in accordance with section V of this Appendix.

**VIII. Maintenance of records, reports, and transfers.**

A. Each licensee shall maintain any records and make any reports in connection with the licensed activities as may be required by the conditions of the license or by the rules, regulations, and orders of the Agency.

B. Records which are required by the regulations in this Part or by license conditions must be maintained for a period specified by the appropriate regulations in this rule or by license condition. If a retention period is not otherwise specified, these records must be maintained and transferred to the officials specified in paragraph E of this section as a condition of license termination unless the Agency otherwise authorizes their disposition.

C. Records which must be maintained pursuant to this Part may be the original or a reproduced copy or a microform if this reproduced copy or microform is capable of producing copy that is clear and legible at the end of the required retention period. 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, specifications, must include all pertinent information such as stamps, initials, and signatures. The licensee shall maintain adequate safeguards against tampering with and loss of records.

D. If there is a conflict between the Agency's regulations in this Part, license condition, or other written Agency approval or authorization pertaining to the retention period for the same type of record, the longest retention period specified takes precedence.

E. Notwithstanding paragraphs A through D of this section, the licensee shall record the location and the quantity of radioactive wastes contained in the disposal site and transfer these records upon license termination to the chief executive of the nearest municipality, the chief executive of the county in which the facility is located, the county zoning board or land development and planning Agency, the State governor and other State, local, and federal governmental agencies as designated by the Agency at the time of license termination.

F. Following receipt and acceptance of a shipment of radioactive waste, the licensee shall record the date of disposal of the waste, the location in the disposal site, the condition of the waste packages as received, any discrepancies between materials listed on the manifest and those received, and any evidence of leaking or damaged packages or radiation or contamination levels in excess of limits specified in U.S. Department of Transportation and Agency regulations. The licensee shall briefly describe any repackaging operations of any of the waste packages included in the shipment, plus any other information required by the Agency as a license condition. The licensee shall retain these records until the Agency transfers or terminates the license that authorizes the activities described in this section.

G. Each licensee shall comply with the safeguards reporting requirements of Part C of this rule if the quantities or activities of materials received or transferred exceed the limits of these sections. Inventory reports required by these sections are not required for materials after disposal.

H. Each licensee authorized to dispose of radioactive waste received from other persons shall file a copy of its financial report or a certified financial statement annually with the Agency in order to update the information base for determining financial qualifications.

1. Each licensee authorized to dispose of waste materials received from other persons, pursuant to this part, shall submit annual reports to the Agency. Reports must be submitted by the end of the first calendar quarter of each year for the preceding year.

2. The reports shall include:

(a) Specification of the quantity of each of the principal radionuclides released to unrestricted areas in liquid and in airborne effluents during the preceding year,

(b) The results of the environmental monitoring program,

(c) A summary of licensee disposal unit survey and maintenance activities,

(d) A summary, by waste class, of activities and quantities of radionuclides disposed of,

(e) Any instances in which observed site characteristics were significantly different from those described in the application for a license; and

(f) Any other information the Agency may require. If the quantities of radioactive materials released during the reporting period, monitoring results, or maintenance performed are significantly different from those expected in the materials previously reviewed as part of the licensing action, the report must cover this specifically.

J. Each licensee shall report in accordance with the requirements of Part C.

K. Any transfer of radioactive materials by the licensee is subject to the requirements in Part C.

**APPENDIX E.**

**NATIONALLY TRACKED SOURCE THRESHOLDS**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **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 |
| Americium-241/Be | 60 | 1,600 | 0.6 | 16 |
| Californium-252 | 20 | 540 | 0.2 | 5.4 |
| Cobalt-60 | 30 | 810 | 0.3 | 8.1 |
| Curium-244 | 50 | 1,400 | 0.5 | 14 |
| Cesium-137 | 100 | 2,700 | 1 | 27 |
| Gadolinium-153 | 1,000 | 27,000 | 10 | 270 |
| Iridium-192 | 80 | 2,200 | 0.8 | 22 |
| Plutonium-238 | 60 | 1,600 | 0.6 | 16 |
| Plutonium-239/Be | 60 | 1,600 | 0.6 | 16 |
| Polonium-210 | 60 | 1,600 | 0.6 | 16 |
| Promethium-147 | 40,000 | 1,100,000 | 400 | 11,000 |
| Radium-226 | 40 | 1,100 | 0.4 | 11 |
| Selenium-75 | 200 | 5,400 | 2 | 54 |
| Strontium-90 | 1,000 | 27,000 | 10 | 270 |
| Thorium-228 | 20 | 540 | 0.2 | 5.4 |
| Thorium-229 | 20 | 540 | 0.2 | 5.4 |
| Thulium-170 | 20,000 | 540,000 | 200 | 5,400 |
| Ytterbium-169 | 300 | 8,100 | 3 | 81 |

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.

**APPENDIX F.**

*(Reserved)*

AP**PENDIX G.**

**SPECIAL REQUIREMENTS INVOLVING**

**LOW-LEVEL RADIOACTIVE WASTE**

**1. Definitions**

A. As used in this Part D Appendix G, the following definitions apply:

(1) **Activity,** as it applies to reporting the radioactivity of waste requiring disposal, refers to the radioactivity of the waste at the time of disposal. If the State did not have access to a disposal facility for that year, the radioactivity of waste placed in storage for that year shall apply (this radioactivity may be calculated to December 31 of the appropriate calendar year).

(2) **Generators of low-level radioactive waste** or generators means any persons who produce or process waste, as defined in Part A, whether or not that waste is shipped off site.

(3) **Minimization plan** means the plan required of each licensee who generates waste requiring disposal, which identifies actions to allow for storage for decay of short-lived radioisotopes and actions to achieve source and volume minimization.

(3) **Mixed waste** means waste that also contain a hazardous component, regulated under subtitle C of the Resource Conservation and Recovery Act (RCRA).

(4) **Source minimization** means minimizing the volume and curie content of waste prior to its generation by such methods as: (1) avoiding unnecessary contamination of items during the use of radioactive materials; (2) carefully segregating waste from non-radioactive trash; (3) substituting non-radioactive isotopes or radioisotopes with shorter half-lives where practicable.

(5) **Storage** means the holding of waste for treatment or disposal.

(6) **Storage for decay** means a procedure in which waste that is authorized by the United States Nuclear Regulatory Commission to be stored at the site of generation for decay and ultimate disposal without regard to radioactivity.

(7) **Volume,** as it applies to reporting volumes of waste requiring disposal, refers to the required space for ultimate disposal at a waste disposal facility. If the State did not have access to a disposal facility for that year, the volume of waste to be disposed of that was placed in storage for that year shall apply.

(8) **Volume minimization** means treatment of waste after its generation in order to minimize the physical dimensions of the waste and the space required for disposal.

**2. Low-level radioactive waste fund**

A. An annual service fee and a compact fee assessment shall be billed by the Agency. These fees are pro-rated such that fifty percent of the fees is based on volume of waste generated and fifty percent is based on the activity of waste generated.

B. Exempted from the annual service fee of Part D. Appendix G.2.A. are the following:

(1) Waste that is authorized by the United States Nuclear Regulatory Commission for disposal without regard to radioactivity;

(2) Waste that is stored for decay;

(3) Radioactive waste or other material that is returned to vendor, including, but not limited to, sealed sources.

C. The annual service fee and compact fee assessment, as specified in Part D. Appendix G.2.A, are determined by data collected on the low-level radioactive waste surveys. These fees will be based on a pro-rata share of the previous years' waste generation.

D. Generators are subject to service fee assessments the year following a termination of their radioactive materials license.

**3. Annual surveys of the low-level radioactive waste stream**

A. Generators of low-level radioactive waste must annually file a low-level radioactive waste survey with the Agency.

B. The low-level radioactive waste survey will require information concerning the volume, activity, isotopic content, chemical form, physical state, packaging, storage for decay, and interim storage capacity of waste and mixed wastes.

C. Completed survey forms must be returned to the Agency within sixty days of the postmarked date.

D. Generators shall maintain copies of their survey forms for the preceding three calendar years.

**4. Advance notification of transportation of low-level radioactive waste**

A. The following reporting requirements are made in addition to the requirements of Parts D.38 and L.19.

B. Three working days prior to the transport of waste outside the confines of the generators' facility or other place of use or storage, or three working days prior to the delivery of any waste to a carrier for transport, each generator shall provide advance notification of such transport to the Agency.

C. Advance notification is required only for waste that is being shipped to a disposal facility.

D. The notification required by Part D Appendix G.4.C. shall contain the following information:

(1) The name, address, and telephone number of the shipper, carrier and receiver of the shipment;

(2) A description of the waste contained in the shipment as required by the regulations of the U. S. Department of Transportation, 49 CFR 172.202 and 172.203;

(3) The point of origin of the shipment;

(4) The destination of the shipment and the seven day period during which arrival of the shipment is estimated to occur;

(5) A point of contact with a telephone number for current shipment information

E. The notification required by Part D Appendix G.4. shall be made in writing to the Agency. A notification delivered by mail must be postmarked seven days prior to the date that the shipment is scheduled to occur. A notification delivered by telephone facsimile or messenger, must be delivered to the Agency at least three working days prior to the date that the shipment is scheduled to occur. A copy of the notification shall be retained by the licensee for one year.

**5. Waste minimization**

A. Generators who generate waste requiring disposal at a rate in excess of 100 cubic feet per calendar year, must submit a waste minimization plan to the Agency on a biennial basis. The plan must include:

(1) A description of the facility and the process or service that generates the waste.

(2) Identification and characterization of the waste streams that result from the process or service.

(3) Analysis of the technical characterization of the waste stream to determine the practicability of source minimization and volume minimization.

(4) Declaration of goals for waste minimization efforts and an analysis of the successfulness of the current waste minimization effort.

B. A detailed existing waste minimization plan may be submitted for Agency approval to meet the requirements of Part D Appendix G.5.A.

**6. Packaging and waste form**

Packaging and waste form of waste for disposal will comply with the requirements of the licensed or registered receiving radioactive waste site or authority.

1. 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 0.5 mSv (0.05 rem) to the embryo/fetus be received in any one month. [↑](#footnote-ref-1)
2. Retrofit shall not be required for locations within facilities where only radiation machines existed prior to January 1, 1994 and met the previous requirements of 5 mSv (0.5 rem) in a year. [↑](#footnote-ref-2)
3. 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. [↑](#footnote-ref-3)
4. Labeled with a Radioactive 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. [↑](#footnote-ref-4)
5. A previous U.S. Nuclear Regulatory Commission rule (10 CFR 20.304) authorized burial of small quantities of licensed materials in soil before January 28, 1981, without specific NRC authorization. [↑](#footnote-ref-5)