

**State of Maine  
Rules Relating  
To  
Radiation Protection**



**Department of Human Services  
Bureau of Health  
Division of Health Engineering**

**11 State House Station  
Augusta, Maine 04333-0011**

**Appropriation # 014-10A-2446**

**10-144A CMR 220 (August 1, 2002)**

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...NOTE: Attention is directed to the fact that regulation by the State of source material, byproduct material, and special nuclear material in quantities not sufficient to form a critical mass is subject to the provisions of the agreement between the State and the U.S. Nuclear Regulatory Commission and to 10 CFR Part 150 of the Commission's regulations.

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## PART C

# LICENSING OF RADIOACTIVE MATERIAL

### 1. Purpose and Scope.

- A. This Part and Parts G and L provide for the licensing of radioactive material and the assignment of fees for such licenses.<sup>1/</sup> No person shall receive, possess, use, transfer, own or acquire radioactive material except as authorized in a specific or general license issued pursuant to this part or as otherwise provided in this part or in a specific or general license issued pursuant to Parts G or L. Fees are specifically addressed in Appendix A to Part C.
- B. In addition to the requirements of this part, all licensees are subject to the requirements of Parts A, D, and J and L of these regulations. Licensees engaged in industrial radiographic operations are subject to the requirements of Part E, licensees using sealed sources radionuclides in the healing arts are subject to the requirements of Part G and licensees engaged in wireline and subsurface tracer studies are subject to the requirements of Part K of these regulations.

### EXEMPTIONS

### 2. Source Material.

- A. Any person is exempt from this part to the extent that such person receives, possesses, uses, owns, or transfers source material in any chemical mixture, compound, solution, or alloy in which the source material is by weight less than 1/20 of 1 percent (0.05 percent) of the mixture, compound, solution, or alloy.
- B. Any person is exempt from this part to the extent that such person receives, possesses, uses, or transfers unrefined and unprocessed ore containing source material; provided that, except as authorized in a specific license, such person shall not refine or process such ore.
- C. Any person is exempt from this part to the extent that such person receives, possesses, uses, or transfers:
- (1) any quantities of thorium contained in:
    - (a) incandescent gas mantles,
    - (b) vacuum tubes,
    - (c) welding rods,
    - (d) electric lamps for illuminating purposes provided that each lamp does not contain more than 50 milligrams of thorium,
    - (e) germicidal lamps, sunlamps, and lamps for outdoor or industrial lighting provided that each lamp does not contain more than 2 grams of thorium,
    - (f) rare earth metals and compounds, mixtures, and products containing not more than 0.25 percent by weight thorium, uranium, or any combination of these, or
    - (g) personnel neutron dosimeters, provided that each dosimeter does not contain more than 50 milligrams of thorium;

<sup>1/</sup> Attention is directed to the fact that regulation by the State of source material, byproduct material, and special nuclear material in quantities not sufficient to form a critical mass is subject to the provisions of the agreement between the State and the U.S. Nuclear Regulatory Commission and to 10 CFR Part 150 of the Commission's regulations.

- (2) source material contained in the following products:
- (a) glazed ceramic tableware, provided that the glaze contains not more than 20 percent by weight source material,
  - (b) glassware containing not more than 10 percent by weight source material, but not including commercially manufactured glass brick, pane glass, ceramic tile or other glass, or ceramic used in construction, or
  - (c) glass enamel and glass enamel frit containing not more than 10 percent by weight source material imported or ordered for importation into the United States, or initially distributed by manufacturers in the United States, before July 25, 1983 <sup>2/</sup>; or
  - (d) piezoelectric ceramic containing not more than 2 percent by weight source material;
- (3) photographic film, negatives, and prints containing uranium or thorium;
- (4) any finished product or part fabricated of, or containing, tungsten-thorium or magnesium-thorium alloys, provided that the thorium content of the alloy does not exceed 4 percent by weight and that this exemption shall not be deemed to authorize the chemical, physical, or metallurgical treatment or processing of any such product or part;
- (5) uranium contained in counterweights installed in aircraft, rockets, projectiles, and missiles, or stored or handled in connection with installation or removal of such counterweights, provided that:
- (a) the counterweights are manufactured in accordance with a specific license issued by the U.S. Nuclear Regulatory Commission, authorizing distribution by the licensee pursuant to 10 CFR Part 40,
  - (b) each counterweight has been impressed with the following legend clearly legible through any plating or other covering: "DEPLETED URANIUM",
  - (c) each counterweight is durably and legibly labeled or marked with the identification of the manufacturer and the statement: "UNAUTHORIZED ALTERATIONS PROHIBITED", and
  - (d) this exemption shall not be deemed to authorize the chemical, physical, or metallurgical treatment or processing of any such counterweights other than repair or restoration of any plating or other covering;
- (6) natural or depleted uranium metal used as shielding constituting part of any shipping container provided that:
- (a) the shipping container is conspicuously and legibly impressed with the legend "CAUTION-RADIOACTIVE SHIELDING-URANIUM", and
  - (b) the uranium metal is encased in mild steel or equally fire resistant metal of minimum wall thickness of one-eighth inch (3.2 mm);
- (7) thorium contained in finished optical lenses, provided that each lens does not contain more than 30 percent by weight of thorium, and that this exemption shall not be deemed to authorize either
- (a) the shaping, grinding, or polishing of such lens or manufacturing processes other than the assembly of such lens into optical systems and devices without any alteration of the lens, or
  - (b) the receipt, possession, use, or transfer of thorium contained in contact lenses, or in spectacles, or in eyepieces in binoculars or other optical instruments;

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<sup>2/</sup> On July 25, 1983, the exemption of glass enamel or glass enamel frit was suspended. The exemption was eliminated on September 11, 1984.

- (8) uranium contained in detector heads for use in fire detection units, provided that each detector head contains not more than 0.005 microcuries of uranium; or
  - (9) thorium contained in any finished aircraft engine part containing nickel-thoria alloy, provided that
    - (a) the thorium is dispersed in the nickel-thoria alloy in the form of finely divided thoria (thorium dioxide), and
    - (b) the thorium content in the nickel-thoria alloy does not exceed 4 percent by weight.
- D. The exemptions in C.2.C do not authorize the manufacture of any of the products described.

### **3. Radioactive Material Other Than Source Material.**

#### **A. Exempt Concentrations**

- (1) Except as provided in C.3.A(2), any person is exempt from this part to the extent that such person receives, possesses, uses, transfers, owns or acquires products containing radioactive material introduced in concentrations not in excess of those listed in Schedule B of this Part.
- (2) No person may introduce radioactive material into a product or material knowing or having reason to believe that it will be transferred to persons exempt under C.3.A(1) or equivalent regulations of the U.S. Nuclear Regulatory Commission, any Agreement State or Licensing State, except in accordance with a specific license issued pursuant to C.11.A. or the general license provided in C.23.

#### **B. Exempt Quantities.**

- (1) Except as provided in C.3.B.3 and 4, any person is exempt from these regulations to the extent that such person receives possesses, uses, transfers, owns, or acquires radioactive material in individual quantities each of which does not exceed the applicable quantity set forth in Schedule B of this part.
- (2) Any person who possesses radioactive material received or acquired under the general license formerly provided in C.6.F(4)(b)(ii) is exempt from the requirements for a license set forth in this part to the extent that such person possesses, uses, transfers or owns such radioactive material. Such exemption does not apply for radium-226.
- (3) This paragraph (C.3.B) does not authorize the production, packaging or repackaging of radioactive material for purposes of commercial distribution, or the incorporation of radioactive material into products intended for commercial distribution.
- (4) No person may, for purposes of commercial distribution, transfer radioactive material in the individual quantities set forth in Schedule B, knowing or having reason to believe that such quantities of radioactive material will be transferred to persons exempt under C.3.B or equivalent regulations of the U.S. Nuclear Regulatory Commission, any Agreement State or Licensing State, except in accordance with a specific license issued by the U.S. Nuclear Regulatory Commission pursuant to Section 32.18 of 10 CFR Part 32 or by the Agency pursuant to C.11.B which license states that the radioactive material may be transferred by the licensee to persons exempt under C.3.B or the equivalent regulations of the U.S. Nuclear Regulatory Commission, any Agreement State or Licensing State.

## C. Exempt Items.

- (1) Certain Items Containing Radioactive Material. Except for persons who apply radioactive material to, or persons who incorporate radioactive material into the following products, any person is exempt from these regulations to the extent that he receives, possesses, uses, transfers, owns, or acquires the following products<sup>3/</sup>
- (a) Timepieces or hands or dials containing not more than the following specified quantities of radioactive material and not exceeding the following specified radiation dose rate:
    - (i) 25 millicuries of tritium per timepiece.
    - (ii) 5 millicuries of tritium per hand.
    - (iii) 15 millicuries of tritium per dial (bezels when used shall be considered as part of the dial).
    - (iv) 100 microcuries of promethium-147 per watch or 200 microcuries of promethium-147 per any other timepiece.
    - (v) 20 microcuries of promethium-147 per watch hand or 40 microcuries of promethium-147 per other timepiece hand.
    - (vi) 60 microcuries of promethium-147 per watch dial or 120 microcuries of promethium-147 per other timepiece dial (bezels when used shall be considered as part of the dial).
    - (vii) The levels of radiation from hands and dials containing promethium-147 will not exceed, when measured through 50 milligrams per square centimeter of absorber:
      - (a) For wrist watches, 0.1 millirad per hour at 10 centimeters from any surface.
      - (b) For pocket watches, 0.1 millirad per hour at 1 centimeter from any surface.
      - (c) For any other timepiece, 0.2 millirad per hour at 10 centimeters from any surface.
    - (viii) One microcurie of radium-226 per timepiece in timepieces acquired prior to the effective date of these regulations.
  - (b) Lock illuminators containing not more than 15 millicuries of tritium or not more than 2 millicuries of promethium-147 installed in automobile locks. The radiation dose rate from each lock illuminator containing promethium-147 will not exceed 1 millirad per hour at 1 centimeter from any surface when measured through 50 milligrams per square centimeter of absorber.
  - (c) Precision balances containing not more than 1 millicurie of tritium per balance or not more than 0.5 millicurie of tritium per balance part.
  - (d) Automobile shift quadrants containing not more than 25 millicuries of tritium.
  - (e) Marine compasses containing not more than 750 millicuries of tritium gas and other marine navigational instruments containing not more than 250 millicuries of tritium gas.

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<sup>3/</sup> Authority to transfer possession or control by the manufacturer, processor, or producer of any equipment, device, commodity, or other product containing byproduct material whose subsequent possession, use, transfer, and disposal by all other persons are exempted from regulatory requirements may be obtained only from the U.S. Nuclear Regulatory Commission, Washington, D.C. 20555.

- (f) Thermostat dials and pointers containing not more than 25 millicuries of tritium per thermostat.
- (g) Electron tubes; provided, that each tube does not contain more than one of the following specified quantities of byproduct material:
  - (i) 150 millicuries of tritium per microwave receiver protector tube or 10 millicuries of tritium per any other electron tube.
  - (ii) 1 microcurie of cobalt-60.
  - (iii) 5 microcuries of nickel-63.
  - (iv) 30 microcuries of krypton-85.
  - (v) 5 microcuries of cesium-137.
  - (vi) 30 microcuries of promethium-147.

And provided further, that the radiation dose rate from each electron tube containing byproduct material does not exceed 1 millirad per hour at 1 centimeter from any surface when measured through 7 milligrams per square centimeter of absorber.<sup>4/</sup>

- (h) Ionizing radiation measuring instruments containing, for purposes of internal calibration or standardization, a source of radioactive material, provided that:
  - (i) Each source contains no more than one exempt quantity set forth in Schedule B of this part, and
  - (ii) Each instrument contains no more than 10 exempt quantities. For purposes of this requirement, an instrument's source(s) may contain either one or different types of radionuclides and an individual exempt quantity may be composed of fractional parts of one or more of the exempt quantities in Schedule B of this part, provided that the sum of such fractions shall not exceed unity.
  - (iii) For purposes of this paragraph, 0.05 microcurie of americium-241 is considered an exempt quantity under Schedule B of this section.
- (j) Spark gap irradiators containing not more than 1 microcurie of cobalt-60 per spark gap irradiator for use in electrically ignited fuel oil burners having a firing rate of at least 3 gallons (11.4 liters) per hour.

(2) Self-Luminous Products Containing Radioactive Material.

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<sup>4/</sup> For purposes of C.3.C.1.(g), "electron tubes" include spark gap tubes, power tubes, gas tubes including glow lamps, receiving tubes, microwave tubes, indicator tubes, pick-up tubes, radiation detection tubes, and any other completely sealed tube that is designed to conduct or control electrical currents.

- (a) Tritium, Krypton-85, or Promethium-147. Except for persons who manufacture, process, or produce self-luminous products containing tritium, krypton-85, or promethium-147, any person is exempt from these regulations to the extent that such person receives, possesses, uses, transfers, owns, or acquires tritium, krypton-85 or promethium-147 in self-luminous products manufactured, processed, produced, imported, or transferred in accordance with a specific license issued by the U.S. Nuclear Regulatory Commission pursuant to Section 32.22 of 10 CFR Part 32, which license authorizes the transfer of the product to persons who are exempt from regulatory requirements. The exemption in C.3.C.2. does not apply to tritium, krypton-85, or promethium-147 used in products primarily for frivolous purposes or in toys or adornments.
  - (b) Radium-226. Any person is exempt from these regulations to the extent that such person receives, possesses, uses, transfers, or owns articles containing less than 0.1 microcurie of radium-226 which were acquired prior to the effective date of these regulations.
- (3) Gas and Aerosol Detectors Containing Radioactive Material.
- (a) Except for persons who manufacture, process, or produce gas and aerosol detectors containing radioactive material, any person is exempt from these regulations to the extent that such person receives, possesses, uses, transfers, owns, or acquires radioactive material in gas and aerosol detectors designed to protect life or property from fires and airborne hazards provided that detectors containing radioactive material shall have been manufactured, imported, or transferred in accordance with a specific license issued by the U.S. Nuclear Regulatory Commission <sup>5/</sup> pursuant to Section 32.26 of 10 CFR Part 32; or a Licensing State pursuant to C.11.C, which authorizes the transfer of the detectors to persons who are exempt from regulatory requirements.
  - (b) Gas and aerosol detectors previously manufactured and distributed to general licensees in accordance with a specific license issued by an Agreement State shall be considered exempt under C.3.C(3)(a), provided that the device is labeled in accordance with the specific license authorizing distribution of the generally licensed device, and provided further that they meet the requirements of C.11.C.
  - (c) Gas and aerosol detectors containing NARM previously manufactured and distributed in accordance with a specific license issued by a Licensing State shall be considered exempt under C.3.C(3)(a), provided that the device is labeled in accordance with the specific license authorizing distribution, and provided further that they meet the requirements of C.11.C.
- (4) Resins Containing Scandium-46 and Designed for Sand Consolidation in Oil Wells. Any person is exempt from these regulations to the extent that such person receives, possesses, uses, transfers, owns or acquires synthetic plastic resins containing scandium-46 which are designed for sand consolidation in oil wells. Such resins shall have been manufactured or imported in accordance with a specific license issued by the U.S. Nuclear Regulatory Commission, or shall have been manufactured in accordance with the specifications contained in a specific license issued by the Agency or any Agreement State to the manufacturer of such resins pursuant to licensing requirements equivalent to those in Sections 32.16 and 32.17 of 10 CFR Part 32 of the regulations of the U.S. Nuclear Regulatory Commission. This exemption does not authorize the manufacture of any resins containing scandium-46.

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<sup>5/</sup> Authority to transfer possession or control by the manufacturer, processor or producer of any equipment, device, commodity, or other product containing byproduct material whose subsequent possession, use, transfer, and disposal by all other persons are exempted from regulatory requirements may be obtained only from the U.S. Nuclear Regulatory Commission, Washington, D.C. 20555.

(5) Radioactive drug: Capsules containing carbon-14 urea for “in-vivo” diagnostic use for humans.

- (a) Except as provided in paragraphs (b) and (c) of this section, any person is exempt from the requirements for a license set forth in the regulations in this part and part G of 10-144A CMR 220, provided that such person receives, possesses, uses, transfers, owns, or acquires capsules containing 37 kBq (1 uCi) carbon-14 urea (allowing for nominal variation that may occur during the manufacturing process) each, for “in-vivo” diagnostic use for humans.
- (b) Any person who desires to use the capsules for research involving human subjects shall apply for and receive a specific license pursuant to part G of 10-144A CMR 220.
- (c) Any person who desires to manufacture, prepare, process, produce, package, repack, or transfer for commercial distribution such capsule shall apply for and receive a specific license pursuant to C.7 of this part.
- (d) Nothing in this section relieves persons from complying with applicable FDA, other Federal, and State requirements governing receipt, administration, and use of drugs.

## LICENSES

**4. Types of Licenses.** Licenses for radioactive materials are of two types: general and specific.

- A. General licenses provided in this part are effective without the filing of applications with the Agency or the issuance of licensing documents to the particular person, although the filing of a certificate with the Agency may be required by the particular general license. The general licensee is subject to all other applicable portions of these regulations and any limitations of the general license.
- B. Specific licenses require the submission of an application to the Agency and the issuance of a licensing document by the Agency. The licensee is subject to all applicable portions of these regulations as well as any limitations specified in the licensing document.

## GENERAL LICENSES

**5. General Licenses - Source Material.**

- A. A general license is hereby issued authorizing commercial and industrial firms, research, educational and medical institutions, and State and local government agencies to use and transfer not more than 15 pounds (6.82 kg) of source material at any one time for research, development, educational, commercial or operational purposes. A person authorized to use or transfer source material, pursuant to this general license may not receive more than a total of 150 pounds (68.2 kg) of source material in any one calendar year.
- B. Persons who receive, possess, use, or transfer source material pursuant to the general license issued in C.5.A. are exempt from the provisions of Parts D and J of these regulations to the extent that such receipt, possession, use, or transfer is within the terms of such general license; provided, however, that this exemption shall not be deemed to apply to any such person who is also in possession of source material under a specific license issued pursuant to this part.
- C. Persons who receive, possess, use, or transfer source material pursuant to the general license in C.5.A. are prohibited from administering source material, or the radiation therefrom, either externally or internally, to human beings except as may be authorized by the Agency in a specific license.
- D. A general license is hereby issued authorizing the receipt of title to source material without regard to quantity. This general license does not authorize any person to receive, possess, use, or transfer source material.

## E. Depleted Uranium in Industrial Products and Devices.

- (1) A general license is hereby issued to receive, acquire, possess, use, or transfer, in accordance with the provisions of C.5.D(2), (3), (4), and (5), depleted uranium contained in industrial products or devices for the purpose of providing a concentrated mass in a small volume of the product or device.
- (2) The general license in C.5.E(1). applies only to industrial products or devices which have been manufactured either in accordance with a specific license issued to the manufacturer of the products or devices pursuant to C.11.L. or in accordance with a specific license issued to the manufacturer by the U.S. Nuclear Regulatory Commission or an Agreement State which authorizes manufacture of the products or devices for distribution to persons generally licensed by the U.S. Nuclear Regulatory Commission or an Agreement State.
- (3) (a) Persons who receive, acquire, possess, or use depleted uranium pursuant to the general license established by C.5.D(1) shall file Agency Form HHE 860 "Registration Certificate - Use of Depleted Uranium Under General License," with the Agency and pay the registration fee referenced in Appendix A of this Part. The form shall be submitted within 30 days after the first receipt or acquisition of such depleted uranium or 30 days after the effective date of these regulations for depleted uranium acquired prior to the effective date. The registrant shall furnish on Agency Form HHE 860 the following information and such other information as may be required by that form:
  - (i) name and address of the registrant;
  - (ii) a statement that the registrant has developed and will maintain procedures designed to establish physical control over the depleted uranium described in C.5.D(1). and designed to prevent transfer of such depleted uranium in any form, including metal scrap, to persons not authorized to receive the depleted uranium; and
  - (iii) name and/or title, address, and telephone number of the individual duly authorized to act for and on behalf of the registrant in supervising the procedures identified in C.5.D(3)(a)(ii).
- (b) The registrant possessing or using depleted uranium under the general license established by C.5.D(1). shall report in writing to the Agency any changes in information furnished by him in Agency Form HHE 860 "Registration Certificate - Use of Depleted Uranium Under General License." The report shall be submitted within 30 days after the effective date of such change.
- (4) A person who receives, acquires, possesses, or uses depleted uranium pursuant to the general license established by C.5.E(1):
  - (a) Shall not introduce such depleted uranium, in any form, into a chemical, physical, or metallurgical treatment or process, except a treatment or process for repair or restoration of any plating or other covering of the depleted uranium.
  - (b) Shall not abandon such depleted uranium.
  - (c) Shall transfer or dispose of such depleted uranium only by transfer in accordance with the provisions of C.21. In the case where the transferee receives the depleted uranium pursuant to the general license established by C.5.E(1), the transferor shall furnish the transferee a copy of this regulation and a copy of Agency Form HHE 860. In the case where the transferee receives the depleted uranium pursuant to a general license contained in the U.S. Nuclear Regulatory Commission's or Agreement State's regulations equivalent to C.5.E(1)., the transferor shall furnish the transferee a copy of this regulation and a copy of Agency Form HHE 860 accompanied by a note explaining that use of the product or device is regulated by the U.S. Nuclear Regulatory Commission or Agreement State under requirements substantially the same as those in this regulation.

- (d) Within 30 days of any transfer, shall report in writing to the Agency the name and address of the person receiving the depleted uranium pursuant to such transfer.
  - (e) Shall not export such depleted uranium except in accordance with the license issued by the U.S. Nuclear Regulatory Commission pursuant to 10 CFR Part 110.
- (5) Any person receiving, acquiring, possessing, using, or transferring depleted uranium pursuant to the general license established by C.5.E(1). is exempt from the requirements of Parts D and J of these regulations with respect to the depleted uranium covered by that general license.

## 6. General Licenses - Radioactive Material Other Than Source Material.

A. Certain Devices and Equipment. A general license is hereby issued to transfer, receive, acquire, own, possess, and use radioactive material incorporated in the following devices or equipment which have been manufactured, tested and labeled by the manufacturer in accordance with a specific license issued to the manufacturer by the U.S. Nuclear Regulatory Commission for use pursuant to Section 31.3 of 10 CFR Part 31. This general license is subject to the provisions of A.4 through A.9, C.3.A(2), C.14, C.21, C.22, and Parts D, J and L of these regulations.

- (1) Static Elimination Device. Devices designed for use as static eliminators, which contain, as a sealed source or sources, radioactive material consisting of a total of not more than 500 microcuries of polonium-210 per device.
- (2) Ion Generating Tube. Devices designed for ionization of air which contain, as a sealed source or sources, radioactive material consisting of a total of not more than 500 microcuries of polonium-210 per device or a total of not more than 50 millicuries of hydrogen-3 (tritium) per device.

B. Certain Measuring, Gauging or Controlling Devices.

- (1) A general license is hereby issued to commercial and industrial firms and to research, educational and medical institutions, individuals in the conduct of their business, and State or local government agencies to own, receive, acquire, possess, use or transfer in accordance with the provision of C.6.B(2), (3), (4), radioactive material, excluding special nuclear material, contained in devices designed and manufactured for the purpose of detecting, measuring, gauging or controlling thickness, density, level, interface location, radiation, leakage, or qualitative or quantitative chemical composition, or for producing light or an ionized atmosphere.
- (2) The general license in C.6.B(1) applies only to radioactive material contained in devices, which have been manufactured and labeled in accordance with the specifications contained in a specific license issued by the Agency pursuant to C.11.D or in accordance with the specifications contained in a specific license issued by the U.S. Nuclear Regulatory Commission, an Agreement State or a Licensing State, which authorizes distribution of devices to persons generally licensed by the U.S. Nuclear Regulatory Commission, an Agreement State or a Licensing State. Regulations under the Federal Food, Drug, and Cosmetic Act authorizing the use of radioactive control devices in food production require certain additional labeling thereon which is found in Section 179.21 of the Code of Federal Regulations, Title 21.
- (3) Any person who owns, receives, acquires, possesses, uses, or transfers radioactive material in a device pursuant to the general license in C.6.B(1) shall file Agency Form HHE 861 "Registration Certificate - Use of Fixed Measuring, Gauging or Controlling Devices" or Agency Form HHE 862 "Registration Certificate - Use of Portable Measuring, Gauging or Controlling Devices" with the Agency. The form shall be submitted within 30 days after the first receipt or acquisition of such device or 30 days after the effective date of these regulations for devices acquired prior to the effective date. The general licensee shall furnish such information as may be required by that form as well as the annual fee referenced in Appendix A of this Part and:

**C.6.B.(3)(a)**

- (a) shall assure that all labels affixed to the device at the time of receipt, and bearing a statement that removal of the label is prohibited, are maintained thereon and shall comply with all instructions and precautions provided by such labels;
- (b) shall assure that the device is tested for leakage of radioactive material and proper operation of the on-off mechanism and indicator, if any, at no longer than six-month intervals or at such other intervals as are specified in the label, however,
  - (i) devices containing only krypton need not be tested for leakage of radioactive material, and
  - (ii) devices containing only tritium or not more than 100 microcuries of other beta and/or gamma emitting material or 10 microcuries of alpha emitting material and devices held in storage in the original shipping container prior to initial installation need not be tested for any purpose;
- (c) shall assure that other testing, installation, servicing, and removal from installation involving the radioactive materials, its shielding or containment, are performed:
  - (i) in accordance with the instructions provided by the labels, or
  - (ii) by a person holding an applicable specific license from the Agency, the U.S. Nuclear Regulatory Commission, an Agreement State or a Licensing State to perform such activities;
- (d) shall maintain records showing compliance with the requirements of C.6.B(3)(b) and (c). The records shall show the results of tests. The records also shall show the dates of performance of, and the names of persons performing, testing, installation, servicing, and removal from installation concerning the radioactive material, its shielding or containment. Records of tests for leakage of radioactive material required by C.6.B(3)(b) shall be maintained for 1 year after the next required leak test is performed or until the sealed source is transferred or disposed. Records of tests of the on/off mechanism and indicator required by C.6.B(3)(b) shall be maintained for 1 year after the next required test of the on/off mechanism and indicator is performed or until the sealed source is transferred or disposed. Records which are required by C.6.B(3)(c). shall be maintained for a period of 2 years from the date of the recorded event or until the device is transferred or disposed;
- (e) upon the occurrence of a failure of or damage to, or any indication of a possible failure of or damage to, the shielding of the radioactive material or the on-off mechanism or indicator, or upon the detection of 0.005 microcurie or more removable radioactive material, shall immediately suspend operation of the device until it has been repaired by the manufacturer or other person holding an applicable specific license from the Agency, the U.S. Nuclear Regulatory Commission, an Agreement State or a Licensing State to repair such devices, or disposed of by transfer to a person authorized by an applicable specific license to receive the radioactive material contained in the device and, within 30 days, furnish to the Agency a report containing a brief description of the event and the remedial action taken;
- (f) shall not abandon the device containing radioactive material;
- (g) except as provided in C.6.B(3)(h), shall transfer or dispose of the device containing radioactive material only by transfer to a specific licensee of the Agency, the U.S. Nuclear Regulatory Commission, an Agreement State or a Licensing State whose specific license authorizes him to receive the device and within 30 days after transfer of a device to a specific licensee shall furnish to the Agency a report containing identification of the device by manufacturer's name and model number and the name and address of the person receiving the device. No report is required if the device is transferred to the specific licensee in order to obtain a replacement device;

(h) shall transfer the device to another general licensee only:

(i) where the device remains in use at a particular location. In such case the transferor shall give the transferee a copy of this regulation and any safety documents identified in the label on the device and within 30 days of the transfer, report to the Agency the manufacturer's name and model number of device transferred, the name and address of the transferee, and the name and/or position of an individual who may constitute a point of contact between the Agency and the transferee; or

(ii) where the device is held in storage in the original shipping container at its intended location of use prior to initial use by a general licensee; and

(j) shall comply with the provisions of D.51. and D.52. of these regulations for reporting radiation incidents, theft, or loss of licensed material, but shall be exempt from the other requirements of Parts D and J of these regulations.

(4) The general license in C.6.B.(1) does not authorize the manufacture of devices containing radioactive material.

(5) The general license provided in C.6.B.(1) is subject to the provisions of A.4 through A.9., C.14., C.21., C.22. and Part L of these regulations.

C. Luminous Safety Devices for Aircraft.

(1) A general license is hereby issued to own, receive, acquire, possess, and use tritium or promethium-147 contained in luminous safety devices for use in aircraft, provided:

(a) each device contains not more than 10 curies of tritium or 300 millicuries of promethium-147; and

(b) each device has been manufactured, assembled or imported in accordance with a specific license issued by the U.S. Nuclear Regulatory Commission, or each device has been manufactured or assembled in accordance with the specifications contained in a specific license issued by the Agency or any Agreement State to the manufacturer or assembler of such device pursuant to licensing requirements equivalent to those in Section 32.53 of 10 CFR Part 32 of the regulations of the U.S. Nuclear Regulatory Commission.

(2) Persons who own, receive, acquire, possess, or use luminous safety devices pursuant to the general license in C.6.C.1. are exempt from the requirements of Part D and Part J of these regulations except that they shall comply with the provisions of D.51. and D.52.

(3) This general license does not authorize the manufacture, assembly, or repair of luminous safety devices containing tritium or promethium-147.

(4) This general license does not authorize the ownership, receipt, acquisition, possession or use of promethium-147 contained in instrument dials.

(5) This general license is subject to the provisions of A.4. through A.9., C.14., C.21., C.22. and Part L of these regulations.

D. Ownership of Radioactive Material. A general license is hereby issued to own radioactive material without regard to quantity. Notwithstanding any other provisions of this part, this general license does not authorize the manufacture, production, transfer, receipt, possession or use of radioactive material.

## E. Calibration and Reference Sources.

- (1) A general license is hereby issued to those persons listed below to own, receive, acquire, possess, use, and transfer, in accordance with the provisions of C.6.E. (4) and (5), americium-241 in the form of calibration or reference sources:
  - (a) Any person who holds a specific license issued by the Agency which authorizes him to receive, possess, use, and transfer radioactive material; and
  - (b) any person who holds a specific license issued by the U.S. Nuclear Regulatory Commission which authorizes him to receive, possess, use, and transfer special nuclear material.
- (2) A general license is hereby issued to own, receive, possess, use, and transfer plutonium in the form of calibration or reference sources in accordance with the provisions of C.6.E. (4) and (5) to any person who holds a specific license issued by the Agency which authorizes him to receive, possess, use, and transfer radioactive material.
- (3) A general license is hereby issued to own, receive, possess, use, and transfer radium-226 in the form of calibration or reference sources in accordance with the provisions of C.6.E. (4) and (5) to any person who holds a specific license issued by the Agency which authorizes him to receive, possess, use, and transfer radioactive material.
- (4) The general licenses in C.6.E.(1),(2) and (3) apply only to calibration or reference sources which have been manufactured in accordance with the specifications contained in a specific license issued to the manufacturer or importer of the sources by the U.S. Nuclear Regulatory Commission pursuant to Section 32.57 of 10 CFR Part 32 or Section 70.39 of 10 CFR Part 70 or which have been manufactured in accordance with the specifications contained in a specific license issued to the manufacturer by the Agency, any Agreement State or Licensing State pursuant to licensing requirements equivalent to those contained in Section 32.57 of 10 CFR Part 32 or Section 70.39 of 10 CFR Part 70 of the regulations of the U.S. Nuclear Regulatory Commission.
- (5) The general licenses provided in C.6.E(1), (2) and (3) are subject to the provisions of A.4 through A.9, C.14, C.21, C.22, and Parts D, J and L of these regulations. In addition, persons who own, receive, acquire, possess, use, or transfer one or more calibration or reference sources pursuant to these general licenses:
  - (a) shall not possess at any one time, at any one location of storage or use, more than 5 microcuries of americium-241, 5 microcuries of plutonium, or 5 microcuries of radium-226 in such sources;
  - (b) shall not receive, possess, use, or transfer such source unless the source, or the storage container, bears a label which includes one of the following statements, as appropriate, or a substantially similar statement which contains the information called for in one of the following statements, as appropriate:
    - (i) The receipt, possession, use and transfer of this source, Model\_\_\_\_\_, Serial No.\_\_\_\_\_, are subject to a general license and the regulations of the U.S. Nuclear Regulatory Commission or of a State with which the Commission has entered into an agreement for the exercise of regulatory authority. Do not remove this label.

**CAUTION - RADIOACTIVE MATERIAL - THIS SOURCE CONTAINS  
(AMERICIUM-241). (PLUTONIUM)<sup>6/</sup>  
DO NOT TOUCH RADIOACTIVE PORTION OF THIS SOURCE.  
(Name of manufacturer or importer)**

<sup>6/</sup> Showing only the name of the appropriate material

- (ii) The receipt, possession, use and transfer of this source, Model \_\_\_\_\_, Serial No. \_\_\_\_\_, are subject to a general license and the regulations of any Licensing State. Do not remove this label.

**CAUTION - RADIOACTIVE MATERIAL - THIS SOURCE CONTAINS RADIUM-226.  
DO NOT TOUCH RADIOACTIVE PORTION OF THIS SOURCE.**

(Name of manufacturer or importer)

- (c) shall not transfer, abandon, or dispose of such source except by transfer to a person authorized by a license from the Agency, the U.S. Nuclear Regulatory Commission, an Agreement State or a Licensing State to receive the source;
- (d) shall store such source, except when the source is being used, in a closed container adequately designed and constructed to contain americium-241, plutonium, or radium-226 which might otherwise escape during storage; and
- (e) shall not use such source for any purpose other than the calibration of radiation detectors or the standardization of other sources.
- (6) These general licenses do not authorize the manufacture of calibration or reference sources containing americium-241, plutonium, or radium-226.

F. General License for Use of Radioactive Material for Certain *In-Vitro* Clinical or Laboratory Testing.

- (1) A general license is hereby issued to any physician, veterinarian, clinical laboratory or hospital to receive, acquire, possess, transfer or use, for any of the following stated tests, in accordance with the provisions of C.6.F. (2), (3), (4), (5), and (6), the following radioactive materials in prepackaged units for use in *in-vitro* clinical or laboratory tests not involving internal or external administration of radioactive material, or the radiation therefrom, to human beings or animals:
- (a) Iodine-125, in units not exceeding 10 microcuries each;
  - (b) Iodine-131, in units not exceeding 10 microcuries each;
  - (c) Carbon-14, in units not exceeding 10 microcuries each;
  - (d) Hydrogen-3 (tritium), in units not exceeding 50 microcuries each;
  - (e) Iron-59, in units not exceeding 20 microcuries each;
  - (f) Cobalt-57, in units not exceeding 10 microcuries each;
  - (g) Selenium-75, in units not exceeding 10 microcuries each;
  - (h) Mock Iodine-125 reference or calibration sources, in units not exceeding 0.05 microcurie of iodine-129 and 0.005 microcurie of americium-241 each;
- (2) No person shall receive, acquire, possess, use or transfer radioactive material pursuant to the general license established by C.6.F.(1). until he has filed Agency Form HHE 863, "Certificate- In Vitro Testing with Radioactive Material Under General License", with the Agency as well as the registration fee referenced in Appendix A to this Part and received from the Agency a validated copy of Agency Form HHE 863 with certification number assigned. The physician, veterinarian, clinical laboratory or hospital shall furnish on Agency Form HHE 863 the following information and such other information as may be required by that form:

**C.6.F.(2)(a)**

- (a) Name and address of the physician, veterinarian, clinical laboratory or hospital;
  - (b) the location of use; and
  - (c) a statement that the physician, veterinarian, clinical laboratory or hospital has appropriate radiation measuring instruments to carry out *in-vitro* clinical or laboratory tests with radioactive material as authorized under the general license in C.6.F.(1). and that such tests will be performed only by personnel competent in the use of such instruments and in the handling of the radioactive material.
- (3) A person who receives, acquires, possesses or uses radioactive material pursuant to the general license established by C.6.F.(1). shall comply with the following:
- (a) The general licensee shall not possess at any one time, pursuant to the general license in C.6.F.(1)., at any one location of storage or use, a total amount of iodine-125, iodine-131, selenium-75, iron-59, and/or cobalt-57 in excess of 200 microcuries.
  - (b) The general licensee shall store the radioactive material, until used, in the original shipping container or in a container providing equivalent radiation protection.
  - (c) The general licensee shall use the radioactive material only for the uses authorized by C.6.F.(1).
  - (d) The general licensee shall not transfer the radioactive material to a person who is not authorized to receive it pursuant to a license issued by the Agency, the U.S. Nuclear Regulatory Commission, any Agreement State or Licensing State, nor transfer the radioactive material in any manner other than in the unopened, labeled shipping container as received from the supplier.
  - (e) The general licensee shall dispose of the Mock Iodine-125 reference or calibration sources described in C.6.F.(1). as required by D.16. of these regulations.
- (4) The general licensee shall not receive, acquire, possess, or use radioactive material pursuant to C.6.F.(1).:
- (a) Except as prepackaged units, which are labeled in accordance with the provisions of an applicable specific license, issued pursuant to C.11.G. or in accordance with the provisions of a specific license issued by the U.S. Nuclear Regulatory Commission, any Agreement State or Licensing State which authorizes the manufacture and distribution of iodine-125, iodine-131, carbon-14, hydrogen-3 (tritium), iron-59, selenium-75, cobalt-57, or Mock Iodine-125 to persons generally licensed under C.6.F or its equivalent, and
  - (b) unless one of the following statements, as appropriate, or a substantially similar statement which contains the information called for in one of the following statements, appears on a label affixed to each prepackaged unit or appears in a leaflet or brochure which accompanies the package:
    - (i) This radioactive material shall be received, acquired, possessed and used only by physicians, veterinarians, clinical laboratories or hospitals and only for *in-vitro* clinical or laboratory tests not involving internal or external administration of the material, or the radiation therefrom, to human beings or animals. Its receipt, acquisition, possession, use, and transfer are subject to the regulations and a general license of the U.S. Nuclear Regulatory Commission or of a State with which the Commission has entered into an agreement for the exercise of regulatory authority.  
(Name of manufacturer)

- (ii) This radioactive material shall be received, acquired, possessed and used only by physicians, veterinarians, clinical laboratories or hospitals and only for *in-vitro* clinical or laboratory tests not involving internal or external administration of the material, or the radiation therefrom, to human beings or animals. Its receipt, acquisition, possession, use and transfer are subject to the regulations and a general license of a Licensing State.  
(Name of manufacturer)

- (5) The physician, veterinarian, clinical laboratory or hospital possessing or using radioactive material under the general license of C.6.F.1. shall report in writing to the Agency, any changes in the information furnished by him in the "Certificate - In-Vitro Testing with Radioactive Material Under General License", Agency Form HHE 880. The report shall be furnished within 30 days after the effective date of such change.
- (6) Any person using radioactive material pursuant to the general license of C.6.F.(1). is exempt from the requirements of Part D and Part J of these regulations with respect to radioactive material covered by that general license, except that such persons using the Mock Iodine-125 described in C.6.F.(1). shall comply with the provisions of D.16, D.28, and D.29 of these regulations.

G. Ice Detection Devices.

- (1) A general license is hereby issued to own, receive, acquire, possess, use, and transfer strontium-90 contained in ice detection devices, provided each device contains not more than 50 microcuries of strontium-90 and each device has been manufactured or imported in accordance with a specific license issued by the U.S. Nuclear Regulatory Commission or each device has been manufactured in accordance with the specifications contained in a specific license issued by the Agency or any Agreement State to the manufacturer of such device pursuant to the licensing requirements equivalent to those in Section 32.61 of 10 CFR Part 32 of the regulations of the U.S. Nuclear Regulatory Commission.
- (2) Persons who own, receive, acquire, possess, use, or transfer strontium-90 contained in ice detection devices pursuant to the general license in C.6.G.(1).,
- (a) shall, upon occurrence of visually observable damage, such as a bend or crack or discoloration from overheating to the device, discontinue use of the device until it has been inspected, tested for leakage and repaired by a person holding a specific license from the U.S. Nuclear Regulatory Commission or an Agreement State to manufacture or service such devices; or shall dispose of the device pursuant to the provisions of D.16 of these regulations;
- (b) shall assure that all labels affixed to the device at the time of receipt, and which bear a statement which prohibits removal of the labels, are maintained thereon; and
- (c) are exempt from the requirements of Part D and Part J of these regulations except that such person shall comply with the provisions of D.33, D.51, and D.52.
- (3) This general license does not authorize the manufacture, assembly, disassembly or repair of strontium-90 in ice detection devices.
- (4) This general license is subject to the provisions of A.4., through A.9., C.14., C.21., C.22., and Part L of these regulations.

## SPECIFIC LICENSES

### 7. Filing Application for Specific Licenses.

- A. Applications for specific license shall be filed on a form prescribed by the Agency.
- B. The Agency may at any time after the filing of the original application, and before the expiration of the license, require further statements in order to enable the Agency to determine whether the license should be modified or revoked.
- C. Each application shall be signed by the applicant or licensee or a person duly authorized to act for and on their behalf.
- D. An application for a license may include a request for a license authorizing one or more activities.
- E. All sections of the application must be completed, clearly and concisely, with the applicable required information.
- F. Applications and documents submitted to the Agency may be made available for public inspection except that the Agency may withhold any document or part thereof from public inspection if disclosure of its content is not required in the public interest and would adversely affect the interest of a person concerned.
- G. Emergency Planning
  - (1) Each application to possess radioactive materials in unsealed form, on foils or plated sources, or sealed in glass in excess of the quantities in "Schedule D -- Quantities of Radioactive Materials Requiring Consideration of the Need for an Emergency Plan for Responding to a Release," must contain either:
    - (a) An evaluation showing that the maximum dose to a person offsite due to a release of radioactive materials would not exceed 1 rem effective dose equivalent or 5 rems to the thyroid or an intake of 2 milligrams of soluble uranium; or
    - (b) An emergency plan for responding to a release of any radioactive material and to any associated chemical hazards directly incident thereto.
  - (2) One or more of the following factors may be used to support an evaluation submitted under paragraph G.1.(a) of this section:
    - (a) The radioactive material is physically separated so that only a portion could be involved in an accident;
    - (b) All or part of the radioactive material is not subject to release during an accident because of the way it is stored or packaged;
    - (c) The release fraction in the respirable size range would be lower than the release fraction shown in Schedule D due to the chemical or physical form of the material;
    - (d) The solubility of the radioactive material would reduce the dose received;
    - (e) Facility design or engineered safety features in the facility would cause the release fraction to be lower than shown in Schedule D;
    - (f) Operating restrictions or procedures would prevent a release fraction as large as that shown in Schedule D;  
or
    - (g) Other factors appropriate for the specific facility.

- (3) An emergency plan for responding to a release of radioactive material submitted under paragraph G.1.(a) of this section must include the following information:
- (a) Facility description. A brief description of the licensee's facility and area near the site.
  - (b) Types of accidents. An identification of each type of radio-active materials accident for which protective actions may be needed.
  - (c) Classification of accidents. A classification system for classifying accidents as alerts or site area emergencies.
  - (d) Detection of accidents. Identification of the means of detecting each type of accident in a timely manner.
  - (e) Mitigation of consequences. A brief description of the means and equipment for mitigating the consequences of each type of accident, including those provided to protect workers onsite, and a description of the program for maintaining the equipment.
  - (f) Assessment of releases. A brief description of the methods and equipment to assess releases of radioactive materials.
  - (g) Responsibilities. A brief description of the responsibilities of licensee personnel should an accident occur, including identification of personnel responsible for promptly notifying offsite response organizations and the Agency; also responsibilities for developing, maintaining, and updating the plan.
  - (h) Notification and coordination. A commitment to and a brief description of the means to promptly notify offsite response organizations and request offsite assistance, including medical assistance for the treatment of contaminated injured onsite workers when appropriate. A control point must be established. The notification and coordination must be planned so that unavailability of some personnel, parts of the facility, and some equipment will not prevent the notification and coordination. The licensee shall also commit to notify this Agency immediately after notification of the appropriate offsite response organizations and not later than one hour after the licensee declares an emergency.
  - (i) Information to be communicated. A brief description of the types of information on facility status, radioactive releases, and recommended protective actions, if necessary, to be given to offsite response organizations and to the Agency.
  - (j) Training. A brief description of the frequency, performance objectives and plans for the training that the licensee will provide workers on how to respond to an emergency including any special instructions and orientation tours the licensee would offer to fire, police, medical and other emergency personnel. The training shall familiarize personnel with site-specific emergency procedures. Also, the training shall thoroughly prepare site personnel for their responsibilities in the event of accident scenarios postulated as most probable for the specific site, including the use of team training for such scenarios.
  - (k) Safe shutdown. A brief description of the means of restoring the facility to a safe condition after an accident.

(l) Exercises. Provisions for conducting quarterly communications checks with offsite response organizations and biennial onsite exercises to test response to simulated emergencies. Quarterly communications checks with offsite response organizations must include the check and update of all necessary telephone numbers. The licensee shall invite offsite response organizations to participate in the biennial exercises. Participation of offsite response organizations in biennial exercises although recommended is not required. Exercises must use accident scenarios postulated as most probable for the specific site and the scenarios shall not be known to most exercise participants. The licensee shall critique each exercise using individuals not having direct implementation responsibility for the plan. Critiques of exercises must evaluate the appropriateness of the plan, emergency procedures, facilities, equipment, training of personnel, and overall effectiveness of the response. Deficiencies found by the critiques must be corrected.

(m) Hazardous chemicals. A certification that the applicant has met its responsibilities under the Emergency Planning and Community Right-to-Know Act of 1986, title III, Pub. L. 99 - 499, if applicable to the applicant's activities at the proposed place of use of the byproduct material.

(4) The licensee shall allow the offsite response organizations expected to respond in case of an accident 60 days to comment on the licensee's emergency plan before submitting it the Agency. The licensee shall provide any comments received within the 60 days to the Agency with the emergency plan.

**8. General Requirements for the Issuance of Specific Licenses. A license application will be approved if the Agency determines that:**

- A. The applicant is qualified by reason of training and experience to use the material in question for the purpose requested in accordance with these regulations in such a manner as to minimize danger to public health and safety or property;
- B. The applicant's proposed equipment, facilities, and procedures are adequate to minimize danger to public health and safety or property;
- C. The issuance of the license will not be inimical to the health and safety of the public; and
- D. The applicant satisfies any applicable special requirements in C.9, C.10. or C.11. and Part E, Part G, and Part K of these regulations.
- E. Environmental Report, Commencement of Construction. In the case of an application for a license to receive and possess radioactive material for commercial waste disposal by land burial, source material milling, or for the conduct of any other activity which the Agency determines will significantly affect the quality of the environment, the Agency, before commencement of construction of the plant or facility in which the activity will be conducted, has concluded, after weighing the environmental, economic, technical and other benefits against environmental costs and considering available alternatives, that the action called for is the issuance of the proposed license, with any appropriate conditions to protect environmental values. Commencement of construction prior to such conclusion shall be grounds for denial of a license to receive and possess radioactive material in such plant or facility. As used in this paragraph the term "commencement of construction" means any clearing of land, excavation, or other substantial action that would adversely affect the environment of a site. The term does not mean site exploration, necessary roads for site exploration, borings to determine foundation conditions, or other preconstruction monitoring or testing to establish background information related to the suitability of the site or the protection of environmental values.

## F. Financial Surety for Decommissioning, Recovery or Site Reclamation.

- (1) Each applicant for a specific license authorizing the possession and use of special nuclear material, source material, or byproduct material in quantities and amounts in excess of those indicated in Table F.1 shall submit a decommissioning funding plan in the event of planned or unplanned decommissioning, recovery, or site reclamation. The decommissioning funding plan must also be submitted when a combination of isotopes is involved if  $R$  divided by  $10^5$  is greater than 1 (unity rule), where  $R$  is defined here as the sum of the ratios of quantity of each isotope to the applicable value in Part C, Appendix E.

TABLE F.1

| Type                     | Exceeding  |
|--------------------------|--|
| Special Nuclear Material | $10^5$ times Part C, App. E  |
| Source Material          | 100 $\mu$ Ci in readily dispersible form                           |
| Byproduct Material       | Half-life greater than 120 days and<br>$10^5$ times Part C, App. E |

- (2) Each applicant for or holder of a specific license authorizing possession and use of special nuclear material, source material, or byproduct material in excess of those indicated in Table F.2 shall either:
- Submit a decommissioning funding plan as described in paragraph (4) of this section; or
  - Submit a certification that financial assurance for decommissioning has been provided in the amount prescribed by Table F.2 of this section using one of the methods described in paragraph (4) of this section. For an applicant, this certification may state that the appropriate assurance will be obtained after the application has been approved and the license issued but prior to the receipt of licensed material.
- (3) Each funding plan must contain a cost estimate for decommissioning, recovery or reclamation, and a description of the method of assuring funds for such including means of adjusting cost estimates and associated funding levels over the life of the facility.

TABLE F.2

| <u>Type of Radioactive Material</u> | <u>Exceeding</u>   | <u>Assurance Amount</u> |
|-------------------------------------|--|-------------------------|
| <u>Special Nuclear</u>              | Greater than $10^4$ but less than or equal to $10^5$ times the applicable quantities*                  | \$500,000               |
|                                     | Greater than $10^3$ but less than or equal to $10^4$ times the applicable quantities*                  | \$100,000               |
| <u>Source Material</u>              | Greater than 10 mCi but less than or equal to 100 mCi in a readily dispersible form                    | \$150,000               |
| <u>Byproduct Material</u>           | Half life greater than 120 days and in quantities:   |                         |
|                                     | Greater than $10^4$ but less than or equal to $10^5$ times the applicable quantities in unsealed form* | \$750,000               |
|                                     | Greater than $10^3$ but less than or equal to $10^4$ times the applicable quantities in unsealed form* | \$150,000               |
|                                     | Greater than $10^{10}$ times the applicable quantities in sealed sources                               | \$75,000                |

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\*\*As indicated in Part C, App. E

(4) Financial assurance must be provided by one or more of the following methods:

- (a) Prepayment. Prepayment is the deposit prior to the start of operation into an account segregated from licensee assets and outside the licensee's administrative control of cash or liquid assets that will retain their value over the projected operating life of the facility and that are in an amount such that the principal plus accumulated earnings would be sufficient to pay the necessary costs. Prepayment may be in the form of a trust, escrow account, government fund, certificate of deposit, or deposit of government securities.

- (b) A surety method insurance, or other guarantee method. These methods guarantee that decommissioning costs will be paid. A surety method may be in the form of a surety bond, letter of credit, or line of credit. A parent company guarantee of funds for decommissioning costs based on a financial test may be used if the guarantee and test are contained in Appendix C of this Part. A parent company guarantee may not be used in combination with other financial methods to satisfy the requirements of this section. A guarantee of funds by the applicant or licensee for decommissioning costs based on a financial test are as contained in Appendix D of this Part. A guarantee by the applicant or licensee may not be used in combination with any other financial methods to satisfy the requirements of this section or in any other situation where the applicant or licensee has a parent company holding majority control of the voting stock of the company. Any surety method or insurance used to provide financial assurance must contain the following conditions:
- (i) The surety or insurance must be open-ended or, if written for a specified term, such as five years, must be renewed automatically unless 90 days or more prior to the renewal date, the issuer notifies the Agency, the beneficiary, and the licensee of its intention not to renew. The surety or insurance must also provide that the beneficiary may automatically collect prior to the expiration without proof of forfeiture if the licensee fails to provide a replacement acceptable to the Agency within 30 days after receipt of notification of cancellation.
  - (ii) The beneficiary of the surety or insurance must be a trustee acceptable to the Agency such as an appropriate state or Federal government agency or a major financial organization.
  - (iii) The surety or insurance must remain in effect until the Agency has terminated the license.
- (c) An external sinking fund in which deposits are made at least annually, coupled with a surety method or insurance, the value of which may decrease by the amount being accumulated in the sinking fund. An external sinking fund is a fund established and maintained by the periodic deposit of a prescribed amount into an account segregated from licensee assets and outside the licensee's administrative control in which the total amount of the periodic deposits plus accumulated earnings would be sufficient to pay the necessary costs at the time termination of operation is expected. An external sinking fund may be in the form of a trust, escrow account, government fund, certificate of deposit, or deposit of government securities.
- (d) In the case of State, or local government licensees, a certification that the appropriate government entity will be guarantor of funds.
- (e) Other funding methods, which are demonstrated by the applicant or licensee to provide comparable assurance to methods, listed in paragraphs (4)(a) through (c) of this section.
- (f) Each person licensed under this Part shall keep records of information important to the safe and effective decommissioning of the facility in an identified location until the license is terminated by the Agency. Before licensed activities are transferred or assigned in accordance with this Part, licensees shall transfer all records described in this paragraph to the new licensee. If records of relevant information are kept for other purposes, reference to these records and their locations may be used. Information the Agency considers important to decommissioning consists of:
- (i) Records of spills or other unusual occurrences involving the spread of contamination in and around the facility, equipment, or site. These records may be limited to instances when contamination remains after any cleanup procedures or when there is reasonable likelihood that contaminants may have spread to inaccessible areas as in the case of possible seepage into porous materials such as concrete.

These records must include any known information on identification of involved nuclides, quantities, forms, and concentrations.

- (ii) As-built drawings and modifications of structures and equipment in restricted areas where radioactive materials are used and/or stored, and of locations of possible inaccessible contamination such as buried pipes, which may be subject to contamination. If required drawings are referenced, each relevant document need not be indexed individually. If drawings are not available, the licensee shall substitute appropriate records of available information concerning these areas and locations.
- (iii) Except for areas containing only sealed sources (provided the sources have not leaked or no contamination remains after any leak) or byproduct materials having only half-lives of less than 65 days, a list contained in a single document and updated every 2 years, of the following:
  - (1) All areas designated and formerly designated restricted areas as defined in D.3;
  - (2) All areas outside of restricted areas that require documentation under C.8.F.(4)(f)(i);
  - (3) All areas outside of restricted areas where current and previous wastes have been buried as documented under D.48; and
  - (4) All areas outside of restricted areas that contain material such that, if the license expired, the licensee would be required to either decontaminate the area to meet the criteria for decommissioning in Part D or apply for approval for disposal under D.34.
- (iv) Records of the cost estimate performed for the decommissioning funding plan or of the amount certified for decommissioning, and records of the funding method used for assuring funds if either a funding plan or certification is used.

## **9. Special Requirements for The Use of Sealed Sources in Industrial Radiography.**

A. In addition to the requirements set forth in C.8, a specific license for use of sealed sources in industrial radiography will be issued if:

- (1) the applicant will have an adequate program for training radiographers and radiographer trainees and submits to the Agency a schedule or description of such program which specifies the:
  - (a) initial training,
  - (b) periodic training,
  - (c) on-the-job training,
  - (d) means to be used by the licensee to determine the radiographer's knowledge and understanding of and ability to comply with Agency regulations and licensing requirements, and the operating and emergency procedures of the applicant, and
  - (e) means to be used by the licensee to determine the radiographer trainees knowledge and understanding of and ability to comply with the operating and emergency procedures of the applicant;

- (2) the applicant has established and submits to the Agency satisfactory written operating and emergency procedures described in E.14 of these regulations;
- (3) the applicant will have an internal inspection system adequate to assure that these regulations, license provisions, and the applicant's operating and emergency procedures are followed by radiographers and radiographer trainees; the inspection system shall include the performance of internal inspections at intervals not to exceed 3 months and the retention of records of such inspections for 2 years;
- (4) the applicant submits to the Agency a description of his overall organizational structure pertaining to the industrial radiography program, including specified delegations of authority and responsibility for operation of the program;
- (5) the applicant who desires to conduct his own leak tests has established adequate procedures to be followed in leak testing sealed sources for possible leakage and contamination and submits to the Agency a description of such procedures including:
  - (a) instrumentation to be used,
  - (b) method of performing tests, e.g., points on equipment to be smeared and method of taking smear, and
  - (c) pertinent experience of the person who will perform the test; and
- (6) the licensee shall conduct a program for inspection and maintenance of radiographic exposure devices and storage containers to assure proper functioning of components important to safety.

**10. Special Requirements for Specific Licenses of Broad Scope.** This section prescribes requirements for the issuance of specific licenses of broad scope for radioactive material and certain regulations governing holders of such licenses. <sup>7/</sup>

A. The different types of broad licenses are set forth below:

- (1) A "Type A specific license of broad scope" is a specific license authorizing receipt, acquisition, ownership, possession, use and transfer of any chemical or physical form of the radioactive material specified in the license, but not exceeding quantities specified in the license, for any authorized purpose. The quantities specified are usually in the multicurie range.
- (2) A "Type B specific license of broad scope" is a specific license authorizing receipt, acquisition, ownership, possession, use and transfer of any chemical or physical form of radioactive material specified in Schedule D, for any authorized purpose. The possession limit for a Type B broad license, if only one radionuclide is possessed thereunder, is the quantity specified for the radionuclide in Schedule D, Column I. If two or more radionuclides are possessed thereunder, the possession limit for each is determined as follows: For each radionuclide, determine the ratio of the quantity possessed to the applicable quantity specified in Schedule D, Column I, for that radionuclide. The sum of the ratios for all radionuclides possessed under the license shall not exceed unity.

<sup>7/</sup> Authority to transfer possession or control by the manufacturer, processor, or producer of any equipment, device, commodity, or other product containing byproduct material whose subsequent possession, use transfer, and disposal by all other persons are exempted from regulatory requirements may be obtained only from the U.S. Nuclear Regulatory Commission, Washington, D.C. 20555.

- (3) A "Type C specific license of broad scope" is a specific license authorizing receipt, acquisition, ownership, possession, use and transfer of any chemical or physical form of radioactive material specified in Schedule D, for any authorized purpose. The possession limit for a Type C broad license, if only one radionuclide is possessed thereunder, is the quantity specified for that radionuclide in Schedule D, Column II. If two or more radionuclides are possessed thereunder, the possession limit is determined for each as follows: For each radionuclide determine the ratio of the quantity possessed to the applicable quantity specified in Schedule D, Column II, for that radionuclide. The sum of the ratios for all radionuclides possessed under the license shall not exceed unity.

B. An application for a Type A specific license of broad scope will be approved if:

- (1) the applicant satisfies the general requirements specified in C.8.;
- (2) the applicant has engaged in a reasonable number of activities involving the use of radioactive material; and
- (3) the applicant has established administrative controls and provisions relating to organization and management, procedures, record keeping, material control and accounting, and management review that are necessary to assure safe operations, including:
  - (a) the establishment of a radiation safety committee composed of such persons as a radiation safety officer, a representative of management, and persons trained and experienced in the safe use of radioactive material;
  - (b) the appointment of a radiation safety officer who is qualified by training and experience in radiation protection, and who is available for advice and assistance on radiation safety matters; and
  - (c) the establishment of appropriate administrative procedures to assure:
    - (i) control of procurement and use of radioactive material;
    - (ii) completion of safety evaluations of proposed uses of radioactive material which take into consideration such matters as the adequacy of facilities and equipment, training and experience of the user, and the operating or handling procedures; and
    - (iii) review, approval, and recording by the radiation safety committee of safety evaluations of proposed uses prepared in accordance with C.10.B.(3). prior to use of the radioactive material.

C. An application for a Type B specific license of broad scope will be approved if:

- (1) the applicant satisfies the general requirements specified in C.8.; and
- (2) the applicant has established administrative controls and provisions relating to organization and management, procedures, record keeping, material control and accounting, and management review that are necessary to assure safe operations, including:
  - (a) the appointment of a radiation safety officer who is qualified by training and experience in radiation protection, and who is available for advice and assistance on radiation safety matters, and
  - (b) the establishment of appropriate administrative procedures to assure:
    - (i) control of procurement and use of radioactive material,

(ii) completion of safety evaluations of proposed uses of radioactive material which take into consideration such matters as the adequacy of facilities and equipment, training and experience of the user, and the operating or handling procedures, and

(iii) review, approval and recording by the radiation safety officer of safety evaluations of proposed uses prepared in accordance with C.10.C.(2). prior to use of the radioactive material.

D. An application for a Type C specific license of broad scope will be approved if:

- (1) the applicant satisfies the general requirements specified in C.8;
- (2) the applicant submits a statement that radioactive material will be used only by, or under the direct supervision of, individuals who have received:
  - (a) a college degree at the bachelor level, or equivalent training and experience, in the physical or biological sciences or in engineering, and
  - (b) at least 40 hours of training and experience in the safe handling of radioactive material, and in the characteristics of ionizing radiation, units of radiation dose and quantities, radiation detection instrumentation, and biological hazards of exposure to radiation appropriate to the type and forms of radioactive material to be used; and
- (3) the applicant has established administrative controls and provisions relating to procurement of radioactive material, procedures, record keeping, material control and accounting, and management review necessary to assure safe operations.

E. Specific licenses of broad scope are subject to the following conditions:

- (1) Unless specifically authorized, persons licensed pursuant to C.10 shall not:
  - (a) conduct tracer studies in the environment involving direct release of radioactive material;
  - (b) receive, acquire, own, possess, use or transfer devices containing 100,000 curies or more of radioactive material in sealed sources used for irradiation of materials;
  - (c) conduct activities for which a specific license issued by the Agency under C.9., or, C.11. or Part G is required; or
  - (d) add or cause the addition of radioactive material to any food, beverage, cosmetic, drug, or other product designed for ingestion or inhalation by, or application to, a human being.
- (2) Each Type A specific license of broad scope issued under this part shall be subject to the condition that radioactive material possessed under the license may only be used by, or under the direct supervision of, individuals approved by the licensee's radiation safety committee.
- (3) Each Type B specific license of broad scope issued under this part shall be subject to the condition that radioactive material possessed under the license may only be used by, or under the direct supervision of, individuals approved by the licensee's radiation safety officer.
- (4) Each Type C specific license of broad scope issued under this part shall be subject to the condition that radioactive material possessed under the license may only be used by, or under the direct supervision of, individuals who satisfy the requirements of C.10.D.

## 11. Special Requirements for a Specific License to Manufacture, Assemble, Repair or Distribute Commodities, Products or Devices which Contain Radioactive Material.

### A. Licensing the Introduction of Radioactive Material into Products in Exempt Concentrations.

- (1) In addition to the requirements set forth in C.8., a specific license authorizing the introduction of radioactive material into a product or material owned by or in the possession of the licensee or another to be transferred to persons exempt under C.3.A.(1). will be issued if:
  - (a) the applicant submits a description of the product or material into which the radioactive material will be introduced, intended use of the radioactive material and the product or material into which it is introduced, method of introduction, initial concentration of the radioactive material in the product or material, control methods to assure that no more than the specified concentrations is introduced into the product or material, estimated time interval between introduction and transfer of the product or material, and estimated concentration of the radioactive material in the product or material at the time of transfer; and
  - (b) the applicant provides reasonable assurance that the concentrations of radioactive material at the time of transfer will not exceed the concentrations in Schedule A, the reconcentration of the radioactive material in concentrations exceeding those in Schedule A is not likely, that use of lower concentrations is not feasible, and that the product or material is not likely to be incorporated in any food, beverage, cosmetic, drug or other commodity or product designed for ingestion or inhalation by, or application to, a human being.
- (2) Each person licensed under C.11.A. shall file an annual report with the Agency which shall identify the type and quantity of each product or material into which radioactive material has been introduced during the reporting period; name and address of the person who owned or possessed the product or material, into which radioactive material has been introduced, at the time of introduction; the type and quantity of radionuclide introduced into each such product or material; and the initial concentrations of the radionuclide in the product or material at time of transfer of the radioactive material by the licensee. If no transfers of radioactive material have been made pursuant to C.11.A. during the reporting period, the report shall so indicate. The report shall cover the year ending June 30, and shall be filed within 30 days thereafter.

### B. Licensing the Distribution of Radioactive Material in Exempt Quantities.<sup>8/</sup>

- (1) An application for a specific license to distribute NARM to persons exempted from these regulations pursuant to C.3.B. will be approved if:
  - (a) the radioactive material is not contained in any food, beverage, cosmetic, drug, or other commodity designed for ingestion or inhalation by, or application to, a human being;
  - (b) the radioactive material is in the form of processed chemical elements, compounds, or mixtures, tissue samples, bioassay samples, counting standards, plated or encapsulated sources, or similar substances, identified as radioactive and to be used for its radioactive properties, but is not incorporated into any manufactured or assembled commodity, product, or device intended for commercial distribution; and

<sup>8/</sup> Authority to transfer possession or control by the manufacturer, processor, or producer of any equipment, device, commodity, or other product containing byproduct material whose subsequent possession, use transfer, and disposal by all other persons are exempted from regulatory requirements may be obtained only from the U.S. Nuclear Regulatory Commission, Washington, D.C. 20555.

- (c) the applicant submits copies of prototype labels and brochures and the Agency approves such labels and brochures.
- (2) The license issued under C.11.B.(1). is subject to the following conditions:
- (a) No more than 10 exempt quantities; shall be sold or transferred in any single transaction. However, an exempt quantity may be composed of fractional parts of one or more of the exempt quantity provided the sum of the fractions shall not exceed unity.
  - (b) Each exempt quantity shall be separately and individually packaged. No more than 10 such packaged exempt quantities shall be contained in any outer package for transfer to persons exempt pursuant to C.4.A. The outer package shall be such that the dose rate at the external surface of the package does not exceed 0.5 millirem per hour.
  - (c) The immediate container of each quantity or separately packaged fractional quantity of radioactive material shall bear a durable, legible label which:
    - (i) identifies the radionuclide and the quantity of radioactivity; and
    - (ii) bears the words "Radioactive Material".
  - (d) In addition to the labeling information required by C.11.B.(2)(c), the label affixed to the immediate container, or an accompanying brochure, shall:
    - (i) state that the contents are exempt from Licensing State requirements;
    - (ii) bear the words "Radioactive Material--Not for Human Use--Introduction into Foods, Beverages, Cosmetics, Drugs, or Medicinals, or into Products Manufactured for Commercial Distribution is Prohibited--Exempt Quantities Should Not Be Combined", and
    - (iii) set forth appropriate additional radiation safety precautions and instructions relating to the handling, use, storage, and disposal of the radioactive material.
- (3) Each person licensed under C.11.B. shall maintain records identifying, by name and address, each person to whom radioactive material is transferred for use under C.3.B. or the equivalent regulations of a Licensing State, and stating the kinds and quantities of radioactive material transferred. An annual summary report stating the total quantity of each radionuclide transferred under the specific license shall be filed with the Agency. Each report shall cover the year ending June 30, and shall be filed within 30 days thereafter. If no transfers of radioactive material have been made pursuant to C.11.B. during the reporting period, the report shall so indicate.

C. Licensing the Incorporation of Naturally Occurring and Accelerator-Produced Radioactive Material into Gas and Aerosol Detectors. An application for a specific license authorizing the incorporation of NARM into gas and aerosol detectors to be distributed to persons exempt under C.3.C.3. will be approved if the application satisfies requirements equivalent to those contained in Section 32.26 of 10 CFR Part 32. The maximum quantity of Radium-226 in each device shall not exceed 0.1 microcurie (3.7 kBq). NARM radionuclides are found in Appendix B to Part C.

D. Licensing the Manufacture and Distribution of Devices to Persons Generally Licensed Under C.6.D.

- (1) An application for a specific license to manufacture or distribute devices containing radioactive material, excluding special nuclear material, to persons generally licensed under C.6.D or equivalent regulations of the U.S. Nuclear Regulatory Commission, an Agreement State or a Licensing State will be approved if:
  - (a) the applicant satisfies the general requirements of C.8.;

- (b) the applicant submits sufficient information relating to the design, manufacture, prototype testing, quality control, labels, proposed uses, installation, servicing, leak testing, operating and safety instructions, and potential hazards of the device to provide reasonable assurance that:
- (i) the device can be safely operated by persons not having training in radiological protection,
  - (ii) under ordinary conditions of handling, storage, and use of the device, the radioactive material contained in the device will not be released or inadvertently removed from the device, and it is unlikely that any person will receive in one year a dose in excess of 10 percent of the limits specified in D.6., and
  - (iii) under accident conditions (such as fire and explosion) associated with handling, storage, and use of the device, it is unlikely that any person would receive an external radiation dose or dose commitment in excess of the following organ doses

| Organ   | Dose              |
|---|-------------------|
| Whole body; head and trunk; active blood-forming organs; gonads; or lens of eye                                     | 15 rems (150 mSv) |
| Hands and forearms; feet and ankles; localized areas of skin averaged over areas no larger than 1 square centimeter | 200 rems (2 Sv)   |
| Other organs  | 50 rems (500 mSv) |

- (c) each device bears a durable, legible, clearly visible label or labels approved by the Agency, which contain in a clearly identified and separate statement:
- (i) instructions and precautions necessary to assure safe installation, operation, and servicing of the device (documents such as operating and service manuals may be identified in the label and used to provide this information),
  - (ii) the requirement, or lack of requirement, for leak testing, or for testing any on-off mechanism and indicator, including the maximum time interval for such testing, and the identification of radioactive material by isotope, quantity of radioactivity, and date of determination of the quantity, and
  - (iii) the information called for in one of the following statements, as appropriate, in the same or substantially similar form:

- (a) The receipt, possession, use, and transfer of this device, Model \_\_\_\_\_<sup>9/</sup>, Serial No. \_\_\_\_\_<sup>9/</sup> are subject to a general license or the equivalent and the regulations of the U.S. Nuclear Regulatory Commission or a State with which the U.S. Nuclear Regulatory Commission has entered into an agreement for the exercise of regulatory authority. This label shall be maintained on the device in a legible condition. Removal of this label is prohibited.

**CAUTION - RADIOACTIVE MATERIAL**

(Name of manufacturer or distributor)

- (b) The receipt, possession, use, and transfer of this device, Model \_\_\_\_\_<sup>9/</sup>, Serial No. \_\_\_\_\_<sup>9/</sup> are subject to a general license or the equivalent, and the regulations of a Licensing State. This label shall be maintained on the device in a legible condition. Removal of this label is prohibited.

**CAUTION - RADIOACTIVE MATERIAL**

(Name of manufacturer or distributor)

- (2) In the event the applicant desires that the device be required to be tested at intervals longer than six months, either for proper operation of the on-off mechanism and indicator, if any, or for leakage of radioactive material or for both, he shall include in his application sufficient information to demonstrate that such longer interval is justified by performance characteristics of the device or similar devices and by design features which have a significant bearing on the probability or consequences of leakage of radioactive material from the device or failure of the on-off mechanism and indicator. In determining the acceptable interval for the test for leakage of radioactive material, the Agency will consider information, which includes, but is not limited to:

- (a) primary containment (source capsule);
- (b) protection of primary containment;
- (c) method of sealing containment;
- (d) containment construction materials;
- (e) form of contained radioactive material;
- (f) maximum temperature withstood during prototype tests;
- (g) maximum pressure withstood during prototype tests;
- (h) maximum quantity of contained radioactive material;

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<sup>9/</sup> The model, serial number, and name of the manufacturer or distributor may be omitted from this label provided the information is elsewhere specified in labeling affixed to the device.

- (i) radiotoxicity of contained radioactive material; and
  - (j) operating experience with identical devices or similarly designed and constructed devices.
- (3) In the event the applicant desires that the general licensee under C.6.D, or under equivalent regulations of the U.S. Nuclear Regulatory Commission, an Agreement State or a Licensing State be authorized to install the device, collect the sample to be analyzed by a specific licensee for leakage of radioactive material, service the device, test the on-off mechanism and indicator, or remove the device from installation, he shall include in his application written instructions to be followed by the general licensee, estimated calendar quarter doses associated with such activity or activities, and bases for such estimates. The submitted information shall demonstrate that performance of such activity or activities by an individual untrained in radiological protection, in addition to other handling, storage, and use of devices under the general license, is unlikely to cause that individual to receive in one year a dose in excess of 10 percent of the limits specified in D.6.
- (4) Each person licensed under C.11.D. to distribute devices to generally licensed persons shall:
- (a) Furnish a copy of the general license contained in C.6.D to each person to whom he directly or through an intermediate person transfers radioactive material in a device for use pursuant to the general license contained in C.6.D.
  - (b) Furnish a copy of the general license contained in the U.S. Nuclear Regulatory Commission's, Agreement State's or Licensing State's regulation equivalent to C.6.D, or alternatively, furnish a copy of the general license contained in C.6.D to each person to whom he directly or through an intermediate person transfers radioactive material in a device for use pursuant to the general license of the U.S. Nuclear Regulatory Commission, the Agreement State or the Licensing State. If a copy of the general license in C.6.D is furnished to such a person, it shall be accompanied by a note explaining that the use of the device is regulated by the U.S. Nuclear Regulatory Commission, Agreement State or Licensing State under requirements substantially the same as those in C.6.D.
  - (c) Report to the Agency all transfers of such devices to persons for use under the general license in C.6.D. Such report shall identify each general licensee by name and address, an individual by name and/or position who may constitute a point of contact between the Agency and the general licensee, the type and model number of device transferred, and the quantity and type of radioactive material contained in the device. If one or more intermediate persons will temporarily possess the device at the intended place of use prior to its possession by the user, the report shall include identification of each intermediate person by name, address, contact, and relationship to the intended user. If no transfers have been made to persons generally licensed under C.6.D. during the reporting period, the report shall so indicate. The report shall cover each calendar quarter and shall be filed within 30 days thereafter.
  - (d) Reports to Other Agencies.
    - (i) Report to the U.S. Nuclear Regulatory Commission all transfers of such devices to persons for use under the U.S. Nuclear Regulatory Commission general license in Section 31.5 of 10 CFR Part 31.
    - (ii) Report to the responsible State Agency all transfers of devices manufactured and distributed pursuant to C.11.D for use under general license in that State's regulations equivalent to C.6.D..

- (iii) Such reports shall identify each general licensee by name and address, an individual by name and/or position who may constitute a point of contact between the agency and the general licensee, the type and model of the device transferred, and the quantity and type of radioactive material contained in the device. If one or more intermediate persons will temporarily possess the device at the intended place of use prior to its possession by the user, the report shall include identification of each intermediate person by name, address, contact, and relationship to the intended user. The report shall be submitted within 30 days after the end of each calendar quarter in which such a device is transferred to the generally licensed person.
  - (iv) If no transfers have been made to U.S. Nuclear Regulatory Commission licensees during the reporting period, this information shall be reported to the U.S. Nuclear Regulatory Commission.
  - (v) If no transfers have been made to general licensees within a particular State during the reporting period, this information shall be reported to the responsible State Agency upon request of the agency.
  - (e) Keep records showing the name, address, and the point of contact for each general licensee to whom he directly or through an intermediate person transfers radioactive material in devices for use pursuant to the general license provided in C.6.D., or equivalent regulations of the U.S. Nuclear Regulatory Commission, an Agreement State or a Licensing State. The records shall show the date of each transfer, the radionuclide and the quantity of radioactivity in each device transferred, the identity of any intermediate person, and compliance with the report requirements of C.11.D.(4).
- E. Special Requirements for the Manufacture, Assembly, or Repair of Luminous Safety Devices for Use in Aircraft. An application for a specific license to manufacture, assemble, or repair luminous safety devices containing tritium or promethium-147 for use in aircraft, for distribution to persons generally licensed under C.6.C will be approved subject to the following conditions:
- (1) The applicant satisfies the general requirements specified in C.8; and
  - (2) the applicant satisfies the requirements of Sections 32.53, 32.54, 32.55, 32.56, 32.101, of 10 CFR Part 32 or their equivalent.
- F. Special Requirements for License to Manufacture Calibration Sources Containing Americium-241, Plutonium or Radium-226 for Distribution to Persons Generally Licensed Under C.6.E. An application for a specific license to manufacture calibration and reference sources containing americium-241, plutonium or radium-226 to persons generally licensed under C.6.E will be approved subject to the following conditions:
- (1) The applicant satisfies the general requirement of C.8; and
  - (2) the applicant satisfies the requirements of Sections 32.57, 32.58, 32.59, 32.102 of 10 CFR Part 32 and Section 70.39 of 10 CFR Part 70 or their equivalent.
- G. Manufacture and Distribution of Radioactive Material for Certain In Vitro Clinical or Laboratory Testing Under General License. An application for a specific license to manufacture or distribute radioactive material for use under the general license of C.6.F will be approved if:
- (1) The applicant satisfies the general requirements specified in C.8.
  - (2) The radioactive material is to be prepared for distribution in prepackaged units of:
    - (a) Iodine-125 in units not exceeding 10 microcuries each.

- (b) Iodine-131 in units not exceeding 10 microcuries each.
  - (c) Carbon-14 in units not exceeding 10 microcuries each.
  - (d) Hydrogen-3 (tritium) in units not exceeding 50 microcuries each.
  - (e) Iron-59 in units not exceeding 20 microcuries each.
  - (f) Cobalt-57 in units not exceeding 10 microcuries each.
  - (g) Selenium-75 in units not exceeding 10 microcuries each.
  - (h) Mock Iodine-125 in units not exceeding 0.05 microcurie of iodine-129 and 0.005 microcurie of americium-241 each.
- (3) Each prepackaged unit bears a durable, clearly visible label:
- (a) Identifying the radioactive contents as to chemical form and radionuclide, and indicating that the amount of radioactivity does not exceed 10 microcuries of iodine-125, iodine-131, carbon-14, cobalt-57, or selenium-75; 50 microcuries of hydrogen-3 (tritium); 20 microcuries of iron-59; or Mock Iodine-125 in units not exceeding 0.05 microcurie of iodine-129 and 0.005 microcurie of americium-241 each; and
  - (b) displaying the radiation caution symbol described in D.27. and the words, "CAUTION, RADIOACTIVE MATERIAL", and "Not for Internal or External Use in Humans or Animals".
- (4) One of the following statements, as appropriate, or a substantially similar statement which contains the information called for in one of the following statements, appears on a label affixed to each prepackaged unit or appears in a leaflet or brochure which accompanies the package:
- (a) **This radioactive material may be received, acquired, possessed, and used only by physicians, veterinarians, clinical laboratories or hospitals and only for in vitro clinical or laboratory tests not involving internal or external administration of the material, or the radiation therefrom, to human beings or animals. Its receipt, acquisition, possession, use, and transfer are subject to the regulations and general license of the U.S. Nuclear Regulatory Commission or of a State with which the Commission has entered into an agreement for the exercise of regulatory authority.**  
(Name of manufacturer)
  - (b) **This radioactive material may be received, acquired, possessed, and used only by physicians, veterinarians, clinical laboratories or hospitals and only for in vitro clinical or laboratory tests not involving internal or external administration of the material, or the radiation therefrom, to human beings or animals. Its receipt, acquisition, possession, use, and transfer are subject to the regulations and a general license of a Licensing State.**  
(Name of manufacturer)
- (5) The label affixed to the unit, or the leaflet or brochure which accompanies the package, contains adequate information as to the precautions to be observed in handling and storing such radioactive material. In the case of the Mock Iodine-125 reference or calibration source, the information accompanying the source must also contain directions to the licensee regarding the waste disposal requirements set out in D.33. of these regulations.

H. Licensing the Manufacture and Distribution of Ice Detection Devices. An application for a specific license to manufacture and distribute ice detection devices to persons generally licensed under C.6.G will be approved subject to the following conditions:

- (1) the applicant satisfies the general requirements of C.8, and
- (2) the criteria of Sections 32.61, 32.62, 32.103 of 10 CFR Part 32 are met.

I. Manufacture and Distribution of Radiopharmaceuticals Containing Radioactive Material for Medical Use Under Part G Licenses.

(1) An application for a specific license to manufacture and distribute radiopharmaceuticals containing radioactive material for use by persons licensed pursuant to Part G for the uses listed in Part G.100, 200 and 300 will be approved if:

(a) The applicant satisfies the general requirements specified in C.8. of this part;

(b) The applicant submits evidence that the applicant is at least one of the following:

- (i) Registered or licensed with the U.S. Food and Drug Administration (FDA) as a drug manufacturer, or
- (ii) Registered or licensed with a state agency as a drug manufacturer; or
- (iii) Licensed as a pharmacy by a State Board of Pharmacy; or
- (iv) Operating as a nuclear pharmacy within a Federal medical institution.

(c) The applicant submits information on the radionuclide; the chemical and physical form; the maximum activity per vial, syringe, generator, or other container of the radioactive drug; and the shielding provided by the packaging to show it is appropriate for the safe handling and storage of the radioactive drugs by medical use licensees; and

(d) The applicant satisfies the following labeling requirements: (i) A label is affixed to each transport radiation shield, whether it is constructed of lead, glass, plastic, or other material, of a radioactive drug to be transferred for commercial distribution. The label must include the radiation symbol and the words "CAUTION, RADIOACTIVE MATERIAL" or "DANGER, RADIOACTIVE MATERIAL"; the name of the radioactive drug or its abbreviation; and the quantity of radioactivity at a specified date and time. For radioactive drugs with a half life greater than 100 days, the time may be omitted.

(ii) A label is affixed to each syringe, vial, or other container used to hold a radioactive drug to be transferred for commercial distribution. The label must include the radiation symbol and the words "CAUTION, RADIOACTIVE MATERIAL" or "DANGER, RADIOACTIVE MATERIAL" and an identifier that ensures that the syringe, vial, or other container can be correlated with the information on the transport radiation shield label.

(2) A licensee described by paragraph (1)(b)(iii) or (iv) of this section:

(a) May prepare radioactive drugs for medical use, as defined in Part G.2, provided that the radioactive drug is prepared by either an authorized nuclear pharmacist, as specified in paragraph (2)(b) and (2)(c) of this section, or an individual under the supervision of an authorized nuclear pharmacist as specified in Part G.

(b) May allow a pharmacist to work as an authorized nuclear pharmacist if:

(i) This individual qualifies as an authorized nuclear pharmacist as defined in Part G.2,

(ii) This individual meets the requirements specified in Part G and the licensee has received an approved license amendment identifying this individual as an authorized nuclear pharmacist, or

(iii) This individual is designated as an authorized nuclear pharmacist in accordance with paragraph (2)(c) of this section.

(c) The actions authorized in paragraphs (2)(a) and (2)(b) of this section are permitted in spite of more restrictive language in license conditions.

(d) May designate a pharmacist (as defined in Part G.2) as an authorized nuclear pharmacist if the individual is identified as of December 2, 1994, as an "authorized user" on a nuclear pharmacy license issued by the Agency under this part.

(e) Shall provide to the Agency a copy of each individual's certification by the Board of Pharmaceutical Specialties, the Commission or Agreement State license, or the permit issued by a licensee of broad scope, and a copy of the state pharmacy licensure or registration, no later than 30 days after the date that the licensee allows, pursuant to paragraphs (2)(b)(i) and (2)(b)(iii) of this section, the individual to work as an authorized nuclear pharmacist.

(3) A licensee shall possess and use instrumentation to measure the radioactivity of radioactive drugs. The licensee shall have procedures for use of the instrumentation. The licensee shall measure, by direct measurement or by combination of measurements and calculations, the amount of radioactivity in dosages of alpha-, beta-, or photon-emitting radioactive drugs prior to transfer for commercial distribution. In addition, the licensee shall:

(a) Perform tests before initial use, periodically, and following repair, on each instrument for accuracy, linearity, and geometry dependence, as appropriate for the use of the instrument; and make adjustments when necessary; and

(b) Check each instrument for constancy and proper operation at the beginning of each day of use.

(4) Nothing in this section relieves the licensee from complying with applicable FDA, other Federal, and State requirements governing radioactive drugs.

J. **Manufacture and Distribution of Generators or Reagent Kits for Preparation of Radiopharmaceuticals Containing Radioactive Material.** An application for a specific license to manufacture and distribute generators or reagent kits containing radioactive material for preparation of radiopharmaceuticals by persons licensed pursuant to Part G.200 will be approved if:

(1) the applicant satisfies the general requirements specified in C.8.;

(2) the applicant submits evidence that:

(a) the generator or reagent kit is to be manufactured, labeled and packaged in accordance with the Federal Food, Drug and Cosmetic Act or the Public Health Service Act, such as a new drug application (NDA) approved by the Food and Drug Administration (FDA), or a "Notice of Claimed Investigational Exemption for a New Drug" (IND) that has been accepted by the FDA, or

- (b) the manufacture and distribution of the generator or reagent kit are not subject to the Federal Food, Drug and Cosmetic Act and the Public Health Service Act;
- (3) the applicant submits information on the radionuclide, chemical and physical form, packaging including maximum activity per package, and shielding provided by the packaging of the radioactive material contained in the generator or reagent kit;
- (4) the label affixed to the generator or reagent kit contains information on the radionuclide, quantity, and date of assay; and
- (5) the label affixed to the generator or reagent kit, or the leaflet or brochure which accompanies the generator or reagent kit, contains:
  - (a) adequate information, from a radiation safety standpoint, on the procedures to be followed and the equipment and shielding to be used in eluting the generator or processing radioactive material with the reagent kit, and
  - (b) a statement that this generator or reagent kit (as appropriate) is approved for use by persons licensed by the Agency pursuant to Part G.200 or under equivalent licenses of the U.S. Nuclear Regulatory Commission, an Agreement State or a Licensing State. The labels, leaflets or brochures required by C.11.J are in addition to the labeling required by FDA and they may be separate from or, with the approval of FDA, may be combined with the labeling required by FDA.

**NOTE:** Although the Agency does not regulate the manufacture and distribution of reagent kits that do not contain radioactive material, it does regulate the use of such reagent kits for the preparation of radiopharmaceuticals containing radioactive material as part of its licensing and regulation of the users of radioactive material. Any manufacturer of reagent kits that do not contain radioactive material who desires to have his reagent kits approved by the Agency for use by persons licensed pursuant to Part G.200 may submit the pertinent information specified in C.11.J.

K. Manufacture and Distribution of Sources or Devices Containing Radioactive Material for Medical Use. An application for a specific license to manufacture and distribute sources and devices containing radioactive material to persons licensed pursuant to Part G for use as a calibration or reference source or for the uses listed in Part G.400. and G.500 will be approved if:

- (1) The applicant satisfies the general requirements in C.8 of this part.
- (2) The applicant submits sufficient information regarding each type of source or device pertinent to an evaluation of its radiation safety, including:
  - (a) the radioactive material contained, its chemical and physical form, and amount,
  - (b) details of design and construction of the source or device,
  - (c) procedures for, and results of, prototype tests to demonstrate that the source or device will maintain its integrity under stresses likely to be encountered in normal use and accidents,
  - (d) for devices containing radioactive material, the radiation profile of a prototype device,
  - (e) details of quality control procedures to assure that production sources and devices meet the standards of the design and prototype tests,
  - (f) procedures and standards for calibrating sources and devices,

- (g) legend and methods for labeling sources and devices as to their radioactive content, and
  - (h) instructions for handling and storing the source or device from the radiation safety standpoint; these instructions are to be included on a durable label attached to the source or device or attached to a permanent storage container for the source or device; provided, the instructions which are too lengthy for such label may be summarized on the label and printed in detail on a brochure which is referenced on the label.
- (3) The label affixed to the source or device, or to the permanent storage container for the source or device, contains information on the radionuclide, quantity, and date of assay, and a statement that the name of source or device is licensed by the Agency for distribution to persons licensed pursuant to Part G sections G.400. and G.500. or under equivalent licenses of the U.S. Nuclear Regulatory Commission, an Agreement State or a Licensing State, provided, that such labeling for sources which do not require long term storage (e.g., gold-198 seeds) may be on a leaflet or brochure which accompanies the source.
  - (4) In the event the applicant desires that the source or device be required to be tested for leakage of radioactive material at intervals longer than six months, he shall include in his application sufficient information to demonstrate that such longer interval is justified by performance characteristics of the source or device or similar sources or devices and by design features that have a significant bearing on the probability or consequences of leakage of radioactive material from the source.
  - (5) In determining the acceptable interval for test of leakage of radioactive material, the Agency will consider information that includes, but is not limited to:
    - (a) primary containment (source capsule),
    - (b) protection of primary containment,
    - (c) method of sealing containment,
    - (d) containment construction materials,
    - (e) form of contained radioactive material,
    - (f) maximum temperature withstood during prototype tests,
    - (g) maximum pressure withstood during prototype tests,
    - (h) maximum quantity of contained radioactive material,
    - (i) radiotoxicity of contained radioactive material, and
    - (j) operating experience with identical sources or devices or similarly designed and constructed sources or devices.

L. Requirements for License to Manufacture and Distribute Industrial Products Containing Depleted Uranium for Mass-Volume Applications.

- (1) An application for specific license to manufacture industrial products and devices containing depleted uranium for use pursuant to C.5.D or equivalent regulations of the U.S. Nuclear Regulatory Commission or an Agreement State will be approved if:
  - (a) the applicant satisfies the general requirements specified in C.8;

- (b) the applicant submits sufficient information relating to the design, manufacture, prototype testing, quality control procedures, labeling or marking, proposed uses, and potential hazards of the industrial product or device to provide reasonable assurance that possession, use, or transfer of the depleted uranium in the product or device is not likely to cause any individual to receive in one year a radiation dose in excess of 10 percent of the limits specified in D.6.; and
  - (c) the applicant submits sufficient information regarding the industrial product or device and the presence of depleted uranium for a mass-volume application in the product or device to provide reasonable assurance that unique benefits will accrue to the public because of the usefulness of the product or device.
- (2) In the case of an industrial product or device whose unique benefits are questionable, the Agency will approve an application for a specific license under C.11.L only if the product or device is found to combine a high degree of utility and low probability of uncontrolled disposal and dispersal of significant quantities of depleted uranium into the environment.
- (3) The Agency may deny any application for a specific license under C.11.L if the end use(s) of the industrial product or device cannot be reasonably foreseen.
- (4) Each person licensed pursuant to C.11.L shall:
- (a) maintain the level of quality control required by the license in the manufacture of the industrial product or device, and in the installation of the depleted uranium into the product or device;
  - (b) label or mark each unit to:
    - (i) identify the manufacturer of the product or device and the number of the license under which the product or device was manufactured, the fact that the product or device contains depleted uranium, and the quantity of depleted uranium in each product or device; and
    - (ii) state that the receipt, possession, use, and transfer of the product or device are subject to a general license or the equivalent and the regulations of the U.S. Nuclear Regulatory Commission or of an Agreement State;
  - (c) assure that the depleted uranium before being installed in each product or device has been impressed with the following legend clearly legible through any plating or other covering: "Depleted Uranium";
  - (d)
    - (i) furnish a copy of the general license contained in C.5.D and a copy of HHE Form 860 to each person to whom he transfers depleted uranium in a product or device for use pursuant to the general license contained in C.5.D, or
    - (ii) furnish a copy of the general license contained in the U.S. Nuclear Regulatory Commission's or Agreement State's regulation equivalent to C.5.D and a copy of the U.S. Nuclear Regulatory Commission's or Agreement State's certificate, or alternatively, furnish a copy of the general license contained in C.5.D and a copy of HHE Form 860 to each person to whom he transfers depleted uranium in a product or device for use pursuant to the general license of the U.S. Nuclear Regulatory Commission or an Agreement State, with a note explaining that use of the product or device is regulated by the U.S. Nuclear Regulatory Commission or an Agreement State under requirements substantially the same as those in C.5.D;

- (e) report to the Agency all transfers of industrial products or devices to persons for use under general license in C.5.D. Such report shall identify each general licensee by name and address, an individual by name and/or position who may constitute a point of contact between the Agency and the general licensee, the type and model number of device transferred, and the quantity of depleted uranium contained in the product or device. The report shall be submitted within 30 days after the end of each calendar quarter in which such a product or device is transferred to the generally licensed person. If no transfers have been made to persons generally licensed under C.5.D during the reporting period, the report shall so indicate;
- (f)
  - (i) report to the U.S. Nuclear Regulatory Commission all transfers of industrial products or devices to persons for use under the U.S. Nuclear Regulatory Commission general license in Section 40.25 of 10 CFR Part 40,
  - (ii) report to the responsible State Agency all transfers of devices manufactured and distributed pursuant to C.11.L for use under a general license in that State's regulations equivalent to C.5.D,
  - (iii) such report shall identify each general licensee by name and address, an individual by name and/or position who may constitute a point of contact between the agency and the general licensee, the type and model number of the device transferred, and the quantity of depleted uranium contained in the product or device. The report shall be submitted within 30 days after the end of each calendar quarter in which such product or device is transferred to the generally licensed person,
  - (iv) if no transfers have been made to U.S. Nuclear Regulatory Commission licensees during the reporting period, this information shall be reported to the U.S. Nuclear Regulatory Commission,
  - (v) if no transfers have been made to general licensees within a particular Agreement State during the reporting period, this information shall be reported to the responsible Agreement State Agency; and
- (g) keep records showing the name, address, and point of contact for each general licensee to whom he transfers depleted uranium in industrial products or devices for use pursuant to the general license provided in C.5.D or equivalent regulations of the U.S. Nuclear Regulatory Commission or an Agreement State. The records shall be maintained for a period of two years and shall show the date of each transfer, the quantity of depleted uranium in each product or device transferred, and compliance with the report requirements of this section.

**12. Special Requirements for Issuance of Specific Licenses for Source Material Milling.**  
*Reserved.*

**13. Issuance of Specific Licenses.**

- A. Upon a determination that an application meets the requirements of the Act and the regulations of the Agency, the Agency will issue a specific license authorizing the proposed activity in such form and containing such conditions and limitations as it deems appropriate or necessary.
- B. The Agency may incorporate in any license at the time of issuance, or thereafter by appropriate rule, regulation, or order, such additional requirements and conditions with respect to the licensee's receipt, possession, use and transfer of radioactive material subject to this part as it deems appropriate or necessary in order to:

- (1) minimize danger to public health and safety or property;
- (2) require such reports and the keeping of such records, and to provide for such inspections of activities under the license as may be appropriate or necessary; and
- (3) prevent loss or theft of material subject to this part.

#### **14. Specific Terms and Conditions of License.**

- A. Each license issued pursuant to this part shall be subject to all provisions of the Act, now or hereafter in effect, and to all rules, regulations, and orders of the Agency.
- B. No license issued or granted under this part and no right to possess or utilize radioactive material granted by any license issued pursuant to this part shall be transferred, assigned, or in any manner disposed of, either voluntarily or involuntarily, directly or indirectly, through transfer of control of any license to any person unless the Agency shall, after securing full information find that the transfer is in accordance with the provisions of the Act, now or hereafter in effect and to all valid rules, regulations and orders of the Agency and shall give its consent in writing.
- C. Each person licensed by the Agency pursuant to this part shall confine his use and possession of the material licensed to the locations and purposes authorized in the license.
- D. Each licensee shall notify the Agency, in writing, immediately following the filing of a voluntary or involuntary petition for bankruptcy under any Chapter of Title 11 (Bankruptcy) of the United States Code by or against:
  - (1) The licensee;
  - (2) An entity (as that term is defined in 11 U.S.C. 101(14)) controlling the licensee or listing the license or licensee as property of the estate; or
  - (3) An affiliate (as that term is defined in 11 U.S.C. 101(2)) of the licensee.
  - (4) This notification must indicate:
    - (a) The bankruptcy court in which the petition for bankruptcy was filed; and
    - (b) The date of the filing of the petition.

#### **15. Expiration and Termination of Licenses**

- A. Except as provided in C.16.B and paragraph .D(3) of this section, each specific license expires at the end of the day, in the month and year stated in the license.
- B. Each licensee shall notify the Agency immediately, in writing, and request termination of the license when the licensee decides to terminate all activities involving materials authorized under the license. The notification and request for termination of the license must include the reports and information specified in paragraphs .D(1)(d) and (e) of this section. The licensee is subject to the provisions of paragraphs (D) and (E) of this section, as applicable.
- C. Each licensee shall notify the Agency immediately, in writing, and request termination of the license when no principal activities under the license have been conducted for a period of 24 months, or no principal activities have been conducted for a period of 24 months in any separate building or outdoor area that contains residual radioactivity such that the building or outdoor area is unsuitable for release in accordance with Agency requirements.

## C.15.D.

D. No less than 30 days before the expiration date specified in a specific license the licensee shall either:

- (1) Submit an application for license renewal under C.16; or
- (2) Notify the Agency in writing if the licensee decides not to renew the license.

E. (1) If a licensee does not submit an application for license renewal under C.16, the licensee shall, on or before the expiration date specified in the license:

- (a) Terminate use of source, byproduct, or special nuclear material, as appropriate;
  - (b) Remove radioactive contamination to the extent practicable except for those procedures covered by paragraph C.15.D(3) of this section;
  - (c) Properly dispose of source material;
  - (d) Submit a completed form, Certificate of Disposition of Material; and
  - (e) Submit a radiation survey report of the premises to confirm the absence of radioactive materials or to establish the levels of residual radioactive contamination, unless the licensee demonstrates the absence of residual radioactive contamination in some other manner. The licensee shall, as appropriate:
    - (i) Report levels of radiation in units of microrads per hour of beta and gamma radiation at one centimeter and gamma radiation at one meter from surfaces and report levels of radioactivity in units of disintegrations per minute (or microcuries) per 100 square centimeters for removable and fixed surfaces, microcuries per milliliter for water, and picocuries per gram for contaminated solids such as soils, or concrete; and
    - (ii) Specify the survey instrument(s) used and certify that each instrument is properly calibrated and tested.
- (2) If no residual radioactive contamination attributable to activities conducted under the license is detected, the licensee shall submit a certification that no detectable radioactive contamination was found. If the information submitted under this paragraph and paragraphs .D(1)(d) and (e) of this section is adequate, the Agency will notify the licensee in writing that the license is terminated.
- (3) (a) If detectable levels of residual radioactive contamination attributable to activities conducted under a license are found, the license continues in effect beyond the expiration date, if necessary, with respect to possession of residual radioactive material present as contamination until the Agency notifies the licensee in writing that the license is terminated. During this time the licensee is subject to the provisions of paragraph (E) of this section.
- (b) In addition to the information submitted under paragraphs D.(1)(d) and (e) of this section the licensee shall submit a plan for decontamination, if required, as regards residual radioactive contamination remaining at the time the license expires.
  - (c) The licensee shall also submit a plan for completion of decommissioning, recovery, or site reclamation if the procedures necessary to carry these out have not been previously approved by the Agency.

F. The proposed decommissioning, recovery, or site reclamation plan, if required by paragraph C.15.D(3) or by license condition, must include:

- (1) Discussion of these planned activities;
- (2) Description of methods used to assure protection of workers and the environment against radiation hazards during such activities;
- (3) A description of the planned final radiation survey; and
- (4) An updated detailed cost estimate, comparison of that estimate with present funds set aside, and plans for assuring the availability of adequate funds for completion of decommissioning, recovery or site reclamation.
- (5) The proposed plan will be approved by the Agency if the information therein demonstrates that the objectives of the plan will be completed as soon as is reasonable and that the health and safety of workers and the public will be adequately protected.

G. Each licensee who possesses residual by-product material, source material, or special nuclear material under paragraph C.15.D(3), following the expiration date specified in the license, shall:

- (1) Limit actions involving source radioactive material to those related to decontamination and other activities related to preparation for release for unrestricted use; and
- (2) Continue to control entry to restricted areas until they are suitable for release for unrestricted use and the Agency notifies the licensee in writing that the license is terminated.

H. As the final step in decommissioning, the licensee shall-

- (1) Certify the disposition of all licensed material, including accumulated wastes, by submitting Maine Form 892 or equivalent information; and
- (2) Conduct a radiation survey of the premises where the licensed activities were carried out and submit a report of the results of this survey, unless the licensee demonstrates in some other manner that the premises are suitable for release in accordance with the criteria for decommissioning in D.60 through D.65. The licensee shall, as appropriate-
  - (i) Report levels of gamma radiation in units of millirems per hour at one meter from surfaces, and report levels of radioactivity, including alpha and beta, in units of microcuries per 100 square centimeters - removable or fixed - for surfaces, microcuries per milliliter for water, and picocuries per gram for solids such as soils or concrete; and
  - (ii) Specify the survey instrument(s) used and certify that each instrument is properly calibrated and tested.

I. Specific licenses, including expired licenses, will be terminated by written notice to the licensee when the Agency determines that:

- (1) Radioactive material has been properly disposed;
- (2) Reasonable effort has been made to eliminate residual radioactive contamination, if present; and
- (3) (i) A radiation survey has been performed which demonstrates that the premises are suitable for release in accordance with the criteria for decommissioning in D.60 through D.65; or

(ii) Other information submitted by the licensee is sufficient to demonstrate that the premises are suitable for release in accordance with the criteria for decommissioning in D.60 through D.65.

(4) Records required by Part D have been received.

**16. Renewal of Licenses.**

A. Applications for renewal of specific licenses shall be filed in accordance with C.7.

B. In any case in which a licensee, not less than 30 days prior to expiration of his existing license, has filed an application in proper form for renewal or for a new license authorizing the same activities, such existing license shall not expire until the application has been finally determined by the Agency.

**17. Amendment of Licenses at Request of Licensee.** Applications for amendment of a license shall be filed in accordance with C.7. and shall specify the respects in which the licensee desires his license to be amended and the grounds for such amendment .

**18. Agency Action on Application to Renew and Amend.** In considering an application by a licensee to renew or amend his license, the Agency will apply the criteria set forth in C.8, and C.9., C.10 or C.11 and Part E, Part G, and Part K of these regulations as applicable.

**19. Persons Possessing a License for Source, Byproduct or Special Nuclear Material in Quantities Not Sufficient to Form a Critical Mass on Effective Date of These Regulations.**

Any person who, on the effective date of these regulations, possesses a general or specific license for source, byproduct, or special nuclear material in quantities not sufficient to form a critical mass, issued by the U.S. Nuclear Regulatory Commission, shall be deemed to possess a like license issued under this part and the Act, such license to expire either 90 days after receipt from the Agency of a notice of expiration of such license, or on the date of expiration specified in the U.S. Nuclear Regulatory Commission license, whichever is earlier.

**20. Persons Possessing Naturally Occurring and Accelerator-Produced Radioactive Material on Effective Date of These Regulations.**

Any person who, on the effective date of these regulations, possesses NARM for which a specific license is required by the Act or this part shall be deemed to possess such a license issued under the Act and this part. Such license shall expire 90 days after the effective date of these regulations; provided, however, that if within the 90 days the person possessing such material files an application in proper form for a license, such existing license shall not expire until the application has been finally determined by the Agency. NARM radionuclides are shown in Appendix B to Part C .

**21. Transfer of Material.**

A. No licensee shall transfer radioactive material except as authorized pursuant to this section.

B. Except as otherwise provided in the license and subject to the provisions of C.21.C and D, any licensee may transfer radioactive material:

(1) to the Agency with prior approval of the agency;

(2) to the U.S. Department of Energy;

(3) to any person exempt from these regulations to the extent permitted under such exemption;

(4) to any person authorized to receive such material under terms of a general license or its equivalent, or a specific license or equivalent licensing document, issued by the agency, the U.S. Nuclear Regulatory Commission, any Agreement State or any Licensing State, or to any person otherwise authorized to receive such material by the Federal Government or any agency thereof, the Agency, any Agreement State or any Licensing State; or

(5) as otherwise authorized by the Agency in writing.

C. Before transferring radioactive material to a specific licensee of the Agency, the U.S. Nuclear Regulatory Commission, an Agreement State or a Licensing State, or to a general licensee who is required to register with the Agency, the U.S. Nuclear Regulatory Commission, an Agreement State or a Licensing State prior to receipt of the radioactive material, the licensee transferring the material shall verify that the transferee's license authorizes the receipt of the type, form, and quantity of radioactive material to be transferred.

D. The following methods for the verification required by C.21.C are acceptable:

(1) The transferor may have in his possession, and read, a current copy of the transferee's specific license or registration certificate;

(2) the transferor may have in his possession a written certification by the transferee that he is authorized by license or registration certificate to receive the type, form, and quantity of radioactive material to be transferred, specifying the license or registration certificate number, issuing agency, and expiration date;

(3) for emergency shipments the transferor may accept oral certification by the transferee that he is authorized by license or registration certificate to receive the type, form, and quantity of radioactive material to be transferred, specifying the license or registration certificate number, issuing agency, and expiration date provided, that the oral certification is confirmed in writing within 10 days;

(4) the transferor may obtain other sources of information compiled by a reporting service from official records of the Agency, the U.S. Nuclear Regulatory Commission, the licensing agency or an Agreement State or a Licensing State as to the identity of licensees and the scope and expiration dates of licenses and registration; or

(5) when none of the methods of verification described in C.21.D 1-4 are readily available or when a transferor desires to verify that information received by one of such methods is correct or up-to-date, the transferor may obtain a record confirmation from the Agency, the U.S. Nuclear Regulatory Commission, or the licensing agency of an Agreement State or a Licensing State that the transferee is licensed to receive the radioactive material.

(6) Preparation for shipment and transport of radioactive material shall be in accordance with the provisions of Part L.

## **22. Modification, Revocation and Termination of Licenses.**

A. The terms and conditions of all licenses shall be subject to amendment, revision, or modification or the license may be suspended or revoked by reason of amendments to the Act, or by reason of rules, regulations and orders issued by the Agency.

B. Any license may be revoked, suspended or modified, in whole or in part, for any material false statement in the application or any statement of fact required under provisions of the Act, or because of conditions revealed by such application or statement of fact or any report, record, or inspection or other means which would warrant the Agency to refuse to grant a license on an original application, or for violation of, or failure to observe any of the terms and conditions of the Act, or of the license, or of any rule, regulation, or order of the Agency.

- C. Except in cases of willfulness or those in which the public health, interest or safety requires otherwise, no license shall be modified, suspended, or revoked unless, prior to the institution of proceedings therefor, facts of conduct which may warrant such action shall have been called to the attention of the licensee in writing and the licensee shall have been accorded an opportunity to demonstrate or achieve compliance with all lawful requirements.
- D. The Agency may terminate a specific license upon request submitted by the licensee to the Agency in writing.

### **23. Deliberate Misconduct.**

A. Any licensee, certificate of registration holder, applicant for a license or certificate of registration, employee of a licensee, certificate of registration holder or applicant; or any contractor (including a supplier or consultant), subcontractor, employee of a contractor or subcontractor of any licensee or certificate of registration holder or applicant for a license or certificate of registration, who knowingly provides to any licensee, applicant, certificate holder, contractor, or subcontractor, any components, equipment, materials, or other goods or services that relate to a licensee's, certificate holder's or applicant's activities in this part, may not:

- (1) Engage in deliberate misconduct that causes or would have caused, if not detected, a licensee, certificate of registration holder, or applicant to be in violation of any rule, regulation, or order; or any term, condition, or limitation of any license issued by the Agency; or
- (2) Deliberately submit to the Agency, a licensee, certificate of registration holder, an applicant, or a licensee's, certificate holder's or applicant's, contractor or subcontractor, information that the person submitting the information knows to be incomplete or inaccurate in some respect material to the Agency.

B. A person who violates paragraph (a)(1) or (a)(2) of this section may be subject to enforcement action in accordance with the procedures Part B.

C. For the purposes of paragraph (a)(1) of this section, deliberate misconduct by a person means an intentional act or omission that the person knows:

- (1) Would cause a licensee, certificate of registration holder or applicant to be in violation of any rule, regulation, or order; or any term, condition, or limitation, of any license issued by the Agency; or
- (2) Constitutes a violation of a requirement, procedure, instruction, contract, purchase order, or policy of a licensee, certificate of registration holder, applicant, contractor, or subcontractor.

## **RECIPROCITY**

### **24. Reciprocal Recognition of Licenses.**

A. Licenses of Byproduct, Source, and Special Nuclear Material in Quantities Not Sufficient to Form a Critical Mass.

(1) Subject to these regulations, any person who holds a specific license from the U.S. Nuclear Regulatory Commission or any Agreement State, and issued by the agency having jurisdiction where the licensee maintains an office for directing the licensed activity and at which radiation safety records are normally maintained, is hereby granted a general license to conduct the activities authorized in such licensing document within this State provided that:

- (a) the licensing document does not limit the activity authorized by such document to specified installations or locations;

## C.24.A.(1)(b)

- (b) the out-of-state licensee notifies the Agency in writing at least 3 working days prior to engaging in such activity and receive Agency approval. Such notification shall indicate the location, period, and type of proposed possession and use within the State, and shall be accompanied by a copy of the pertinent licensing document and HHE form 865. If, for a specific case, the 3 working day period would impose an undue hardship on the out-of-state licensee, he may, upon application to the Agency, obtain permission to proceed sooner. The Agency requires that the applicable Maine annual license fee accompany the initial request for reciprocity (see table 1 to appendix A of this part). This reciprocity fee will cover a period of one year from the time of application, at which time a new fee submittal will be required. This requirement does not waive the requirement for filing additional written notifications during the remainder of the calendar year following the receipt of the initial notification from a person engaging in activities under the general license provided in C.23.A(1).
  - (c) the out-of-state licensee complies with all applicable regulations of the Agency and with all the terms and conditions of his licensing document, except any such terms and conditions which may be inconsistent with applicable regulations of the Agency;
  - (d) the out-of-state licensee supplies such other information as the Agency may request; and
  - (e) the out-of-state licensee shall not transfer or dispose of radioactive material possessed or used under the general license provided in C.23.A(1) except by transfer to a person:
    - (i) specifically licensed by the Agency or by the U.S. Nuclear Regulatory Commission to receive such material, or
    - (ii) exempt from the requirements for a license for such material under C.3.
- (2) Notwithstanding the provisions of C.23.A(1), any person who holds a specific license issued by the U.S. Nuclear Regulatory Commission or an Agreement State authorizing the holder to manufacture, transfer, install, or service a device described in C.6.B(1) within areas subject to the jurisdiction of the licensing body is hereby granted a general license to install, transfer, demonstrate or service such a device in this State provided that: (a) the device has been manufactured, labeled, installed, and serviced in accordance with applicable provisions of the specific license issued to such person by the U.S. Nuclear Regulatory Commission or an Agreement State;
- (b) such person shall assure that any labels required to be affixed to the device under regulations of the authority, which licensed manufacture of the device, bear a statement that "Removal of this label is prohibited";
  - (c) Such person shall file Agency Form HHE 867 "Registration Certificate – Service of Generally Licensed devices". The form shall be submitted within 30 days after the first entry or 30 days after the effective date of these regulations for persons in state prior to the effective date. The general licensee shall furnish such information as may be required by that form as well as the annual fee referenced in Appendix A of this Part. This registration fee will cover a period of one year from the time of application, at which time a new fee submittal will be required.
- (3) The Agency may withdraw, limit, or qualify its acceptance of any specific license or equivalent licensing document issued by another agency the U.S. Nuclear Regulatory Commission or an Agreement State, or any product distributed pursuant to such licensing document, upon determining that such action is necessary in order to prevent undue hazard to public health and safety or property.

## B. Licenses of Naturally Occurring and Accelerator-Produced Radioactive Material.

## C.24.B.(1)

- (1) Subject to these regulations, any person who holds a specific license from any Licensing State, and issued by the agency having jurisdiction where the licensee maintains an office for directing the licensed activity and at which radiation safety records are normally maintained, is hereby granted a general license to conduct the activities authorized in such licensing document within this State provided that:
  - (a) the licensing document does not limit the activity authorized by such document to specified installations or locations;
  - (b) the out-of-state licensee notifies the Agency in writing at least 3 working days prior to engaging in such activity and receive Agency approval. Such notification shall indicate the location, period, and type of proposed possession and use within the State, and shall be accompanied by a copy of the pertinent licensing document and HHE form 865. If, for a specific case, the 3 working day period would impose an undue hardship on the out-of-state licensee, he may, upon application to the Agency, obtain permission to proceed sooner. The Agency requires that the applicable Maine annual license fee accompany the initial request for reciprocity (see table 1 to appendix A of this part). This reciprocity fee will cover a period of one year from the time of application, at which time a new fee submittal will be required. This requirement does not waive the requirement for filing additional written notifications during the remainder of the calendar year following the receipt of the initial notification from a person engaging in activities under the general license provided in C.23.B(1).
  - (c) the out-of-state licensee complies with all applicable regulations of the Agency and with all the terms and conditions of his licensing document, except any such terms and conditions which may be inconsistent with applicable regulations of the Agency;
  - (d) the out-of-state licensee supplies such other information as the Agency may request; and
  - (e) the out-of-state licensee shall not transfer or dispose of radioactive material possessed or used under the general license provided in C.23.B(1) except by transfer to a person:
    - (i) specifically licensed by the Agency or by another Licensing State to receive such material, or
    - (ii) exempt from the requirements for a license for such material under C.3.
- (2) Notwithstanding the provisions of C.23.B(1), any person who holds a specific license issued by a Licensing State authorizing the holder to manufacture, transfer, install, or service a device described in C.6.B(1) within areas subject to the jurisdiction of the licensing body is hereby granted a general license to install, transfer, demonstrate or service such a device in this State provided that:
  - (a) The device has been manufactured, labeled, installed, and serviced in accordance with applicable provisions of the specific license issued to such person by a Licensing State;
  - (b) Such person shall assure that any labels required to be affixed to the device under regulations of the authority which licensed manufacture of the device bear a statement that "Removal of this label is prohibited"; and
  - (c) Such person shall file Agency Form HHE 867 "Registration Certificate – Service of Generally Licensed devices". The form shall be submitted within 30 days after the first entry or 30 days after the effective date of these regulations for persons in state prior to the effective date. The general licensee shall furnish such information as may be required by that form as well as the annual fee referenced in Appendix A of this Part. This registration fee will cover a period of one year from the time of application, at which time a new fee submittal will be required.

C. The Agency may withdraw, limit or qualify its acceptance of any specific license or equivalent licensing document issued by another agency, or any product distributed pursuant to such licensing document, upon determining that such action is necessary in order to prevent undue hazard to public health and safety or property.

## SCHEDULE A

### EXEMPT CONCENTRATIONS OF RADIOACTIVE MATERIALS WHICH ARE INTRODUCED INTO PRODUCTS (PART C.3.A)

| Element (atomic number) | Isotope | Column I<br>Gas Concentration<br>$\mu\text{Ci/ml}^{1/}$ | Column II<br>Liquid and Solid<br>Concentration<br>$\mu\text{Ci/ml}^{2/}$ |
|-------------------------|---------|---|--|
| Antimony (51)           | Sb-122  |   | $3 \times 10^{-4}$   |
|                         | Sb-124  |   | $2 \times 10^{-4}$   |
|                         | Sb-125  |   | $1 \times 10^{-3}$   |
| Argon (18)              | Ar-37   | $1 \times 10^{-3}$                                      |  |
|                         | Ar-41   | $4 \times 10^{-7}$                                      |  |
| Arsenic (33)            | As-73   |   | $5 \times 10^{-3}$   |
|                         | As-74   |   | $5 \times 10^{-4}$   |
|                         | As-76   |   | $2 \times 10^{-4}$   |
|                         | As-77   |   | $8 \times 10^{-4}$   |
| Barium (56)             | Ba-131  |   | $2 \times 10^{-3}$   |
|                         | Ba-140  |   | $3 \times 10^{-4}$   |
| Beryllium (4)           | Be-7    |   | $2 \times 10^{-2}$   |
| Bismuth (83)            | Bi-206  |   | $4 \times 10^{-4}$   |
| Bromine (35)            | Br-82   | $4 \times 10^{-7}$                                      | $3 \times 10^{-3}$   |
| Cadmium (48)            | Cd-109  |   | $2 \times 10^{-3}$   |
|                         | Cd-115m |   | $3 \times 10^{-4}$   |
|                         | Cd-115  |   | $3 \times 10^{-4}$   |
| Calcium (20)            | Ca-45   |   | $9 \times 10^{-5}$   |
|                         | Ca-47   |   | $5 \times 10^{-4}$   |
| Carbon (6)              | C-14    | $1 \times 10^{-6}$                                      | $8 \times 10^{-3}$   |
| Cerium (58)             | Ce-141  |   | $9 \times 10^{-4}$   |
|                         | Ce-143  |   | $4 \times 10^{-4}$   |
|                         | Ce-144  |   | $1 \times 10^{-4}$   |
| Cesium (55)             | Cs-131  |   | $2 \times 10^{-2}$   |
|                         | Cs-134m |   | $6 \times 10^{-2}$   |
|                         | Cs-134  |   | $9 \times 10^{-5}$   |
| Chlorine (17)           | Cl-38   | $9 \times 10^{-7}$                                      | $4 \times 10^{-3}$   |
| Chromium (24)           | Cr-51   |   | $2 \times 10^{-2}$   |
| Cobalt (27)             | Co-57   |   | $5 \times 10^{-3}$   |
|                         | Co-58   |   | $1 \times 10^{-3}$   |
|                         | Co-60   |   | $5 \times 10^{-4}$   |
| Copper (29)             | Cu-64   |   | $3 \times 10^{-3}$   |

1/ Values are given in Column I only for those materials normally used as gases.

2/  $\mu\text{Ci/gm}$  for solids.

C. Schedule A

| Element (atomic number) | Isotope               | Column I                                    | Column II   |
|-------------------------|-----------------------|---|---|
|                         |                       | Gas Concentration<br>$\mu\text{Ci/ml}^{1/}$ | Liquid and Solid<br>Concentration<br>$\mu\text{Ci/ml}^{2/}$ |
| Dysprosium (66)         | Dy-165                |   | $4 \times 10^{-5}$  |
|                         | Dy-166                |   | $4 \times 10^{-4}$  |
| Erbium (68)             | Er-169                |   | $9 \times 10^{-4}$  |
|                         | Er-171                |   | $1 \times 10^{-3}$  |
| Europium (63)           | Eu-152                |   | $6 \times 10^{-4}$  |
|                         | (Tr=9.2 hr)<br>Eu-155 |   | $2 \times 10^{-3}$  |
| Fluorine (9)            | F-18                  | $2 \times 10^{-6}$                          | $8 \times 10^{-3}$  |
| Gadolinium (64)         | Gd-153                |   | $2 \times 10^{-3}$  |
|                         | Gd-159                |   | $8 \times 10^{-4}$  |
| Gallium (31)            | Ga-72                 |   | $4 \times 10^{-4}$  |
| Germanium (32)          | Ge-71                 |   | $2 \times 10^{-2}$  |
| Gold (79)               | Au-196                |   | $2 \times 10^{-3}$  |
|                         | Au-198                |   | $5 \times 10^{-4}$  |
|                         | Au-199                |   | $2 \times 10^{-3}$  |
| Hafnium (72)            | Hf-181                |   | $7 \times 10^{-4}$  |
| Hydrogen (1)            | H-3                   | $5 \times 10^{-6}$                          | $3 \times 10^{-2}$  |
| Indium (49)             | In-113m               |   | $1 \times 10^{-2}$  |
|                         | In-114m               |   | $2 \times 10^{-4}$  |
| Iodine (53)             | I-126                 | $3 \times 10^{-9}$                          | $2 \times 10^{-5}$  |
|                         | I-131                 | $3 \times 10^{-9}$                          | $2 \times 10^{-5}$  |
|                         | I-132                 | $8 \times 10^{-8}$                          | $6 \times 10^{-4}$  |
|                         | I-133                 | $1 \times 10^{-8}$                          | $7 \times 10^{-5}$  |
|                         | I-134                 | $2 \times 10^{-7}$                          | $1 \times 10^{-3}$  |
| Iridium (77)            | Ir-190                |   | $2 \times 10^{-3}$  |
|                         | Ir-192                |   | $4 \times 10^{-4}$  |
|                         | Ir-194                |   | $3 \times 10^{-4}$  |
| Iron (26)               | Fe-55                 |   | $8 \times 10^{-3}$  |
|                         | Fe-59                 |   | $6 \times 10^{-4}$  |
| Krypton (36)            | Kr-85m                | $1 \times 10^{-6}$                          |   |
|                         | Kr-85                 | $3 \times 10^{-6}$                          |   |
| Lanthanum (57)          | La-140                |   | $2 \times 10^{-4}$  |
| Lead (82)               | Pb-203                |   | $4 \times 10^{-3}$  |
| Lutetium (71)           | Lu-177                |   | $1 \times 10^{-3}$  |
| Manganese (25)          | Mn-52                 |   | $3 \times 10^{-4}$  |
|                         | Mn-54                 |   | $1 \times 10^{-3}$  |
|                         | Mn-56                 |   | $1 \times 10^{-3}$  |

1/ Values are given in Column I only for those materials normally used as gases.

2/  $\mu\text{Ci/gm}$  for solids.

C. Schedule A

| Element (atomic number)  | Isotope | Column I                                    | Column II   |
|--------------------------|---------|---|---|
|                          |         | Gas Concentration<br>$\mu\text{Ci/ml}^{1/}$ | Liquid and Solid<br>Concentration<br>$\mu\text{Ci/ml}^{2/}$ |
| Mercury (80)             | Hg-197m |   | $2 \times 10^{-3}$  |
|                          | Hg-197  |   | $3 \times 10^{-3}$  |
|                          | Hg-203  |   | $2 \times 10^{-4}$  |
| Molybdenum (42)          | Mo-99   |   | $2 \times 10^{-3}$  |
| Neodymium (60)           | Nd-147  |   | $6 \times 10^{-4}$  |
|                          | Nd-149  |   | $3 \times 10^{-3}$  |
| Nickel (28)              | Ni-65   |   | $1 \times 10^{-3}$  |
| Niobium (Columbium) (41) | Nb-95   |   | $1 \times 10^{-3}$  |
|                          | Nb-97   |   | $9 \times 10^{-3}$  |
| Osmium (76)              | Os-185  |   | $7 \times 10^{-4}$  |
|                          | Os-191m |   | $3 \times 10^{-2}$  |
|                          | Os-191  |   | $2 \times 10^{-3}$  |
|                          | Os-193  |   | $6 \times 10^{-4}$  |
| Palladium (46)           | Pd-103  |   | $3 \times 10^{-3}$  |
|                          | Pd-109  |   | $9 \times 10^{-4}$  |
| Phosphorus (15)          | P-32    |   | $2 \times 10^{-4}$  |
| Platinum (78)            | Pt-191  |   | $1 \times 10^{-3}$  |
|                          | Pt-193m |   | $1 \times 10^{-2}$  |
|                          | Pt-197m |   | $1 \times 10^{-2}$  |
|                          | Pt-197  |   | $1 \times 10^{-3}$  |
| Potassium (19)           | K-42    |   | $3 \times 10^{-3}$  |
| Praseodymium (59)        | Pr-142  |   | $3 \times 10^{-4}$  |
|                          | Pr-143  |   | $5 \times 10^{-4}$  |
| Promethium (61)          | Pm-147  |   | $2 \times 10^{-3}$  |
|                          | Pm-149  |   | $4 \times 10^{-4}$  |
| Rhenium (75)             | Re-183  |   | $6 \times 10^{-3}$  |
|                          | Re-186  |   | $9 \times 10^{-4}$  |
|                          | Re-188  |   | $6 \times 10^{-4}$  |
| Rhodium (45)             | Rh-103m |   | $1 \times 10^{-1}$  |
|                          | Rh-105  |   | $1 \times 10^{-3}$  |
| Rubidium (37)            | Rb-86   |   | $7 \times 10^{-4}$  |
| Ruthenium (44)           | Ru-97   |   | $4 \times 10^{-3}$  |
|                          | Ru-103  |   | $8 \times 10^{-4}$  |
|                          | Ru-105  |   | $1 \times 10^{-3}$  |
|                          | Ru-106  |   | $1 \times 10^{-4}$  |
| Samarium (62)            | Sm-153  |   | $8 \times 10^{-4}$  |

1/ Values are given in Column I only for those materials normally used as gases.

2/  $\mu\text{Ci/gm}$  for solids.

C. Schedule A

| Element (atomic number) | Isotope | Column I                                  | Column II   |
|-------------------------|---------|---|---|
|                         |         | Gas Concentration<br>$\mu\text{Ci/ml}^1/$ | Liquid and Solid<br>Concentration<br>$\mu\text{Ci/ml}^2/$ |
| Scandium (21)           | Sc-46   |   | $4 \times 10^{-4}$  |
|                         | Sc-47   |   | $9 \times 10^{-4}$  |
|                         | Sc-48   |   | $3 \times 10^{-4}$  |
| Selenium (34)           | Se-75   |   | $3 \times 10^{-3}$  |
| Silicon (14)            | Si-31   |   | $9 \times 10^{-3}$  |
| Silver (47)             | Ag-105  |   | $1 \times 10^{-3}$  |
|                         | Ag-110m |   | $3 \times 10^{-4}$  |
|                         | Ag-111  |   | $4 \times 10^{-4}$  |
| Sodium (11)             | Na-24   |   | $2 \times 10^{-3}$  |
| Strontium (38)          | Sr-85   |   | $1 \times 10^{-3}$  |
|                         | Sr-91   |   | $7 \times 10^{-4}$  |
|                         | Sr-92   |   | $7 \times 10^{-4}$  |
| Sulfur (16)             | S-35    | $9 \times 10^{-8}$                        | $6 \times 10^{-4}$  |
| Tantalum (73)           | Ta-182  |   | $4 \times 10^{-4}$  |
| Technetium (43)         | Tc-96m  |   | $1 \times 10^{-1}$  |
|                         | Sr-89   |   | $1 \times 10^{-4}$  |
|                         | Tc-96   |   | $1 \times 10^{-3}$  |
| Tellurium (52)          | Te-125m |   | $2 \times 10^{-3}$  |
|                         | Te-127m |   | $6 \times 10^{-4}$  |
|                         | Te-127  |   | $3 \times 10^{-3}$  |
|                         | Te-129m |   | $3 \times 10^{-4}$  |
|                         | Te-131m |   | $6 \times 10^{-4}$  |
|                         | Te-132  |   | $3 \times 10^{-4}$  |
| Terbium (65)            | Tb-160  |   | $4 \times 10^{-4}$  |
| Thallium (81)           | Tl-200  |   | $4 \times 10^{-3}$  |
|                         | Tl-201  |   | $3 \times 10^{-3}$  |
|                         | Tl-202  |   | $1 \times 10^{-3}$  |
|                         | Tl-204  |   | $1 \times 10^{-3}$  |
| Thulium (69)            | Tm-170  |   | $5 \times 10^{-4}$  |
|                         | Tm-171  |   | $5 \times 10^{-3}$  |
| Tin (50)                | Sn-113  |   | $9 \times 10^{-4}$  |
|                         | Sn-125  |   | $2 \times 10^{-4}$  |
| Tungsten (Wolfram) (74) | W-181   |   | $4 \times 10^{-3}$  |
|                         | W-187   |   | $7 \times 10^{-4}$  |
| Vanadium (23)           | V-48    |   | $3 \times 10^{-4}$  |

1/ Values are given in Column I only for those materials normally used as gases.

2/  $\mu\text{Ci/gm}$  for solids.

C. Schedule A

| Element (atomic number)   | Isotope | Column I                                  | Column II   |
|---|---------|---|---|
|   |         | Gas Concentration<br>μCi/ml <sup>1/</sup> | Liquid and Solid<br>Concentration<br>μCi/ml <sup>2/</sup> |
| Xenon (54)  | Xe-131m | 4X10 <sup>-6</sup>                        |   |
|   | Xe-133  | 3X10 <sup>-6</sup>                        |   |
|   | Xe-135  | 1X10 <sup>-6</sup>                        |   |
| Ytterbium (70)  | Yb-175  |   | 1X10 <sup>-3</sup>  |
| Yttrium (39)  | Y-90    |   | 2X10 <sup>-4</sup>  |
|   | Y-91m   |   | 3X10 <sup>-2</sup>  |
|   | Y-91    |   | 3X10 <sup>-4</sup>  |
|   | Y-92    |   | 6X10 <sup>-4</sup>  |
|   | Y-93    |   | 3X10 <sup>-4</sup>  |
| Zinc (30)   | Zn-65   |   | 1X10 <sup>-3</sup>  |
|   | Zn-69m  |   | 7X10 <sup>-4</sup>  |
|   | Zn-69   |   | 2X10 <sup>-2</sup>  |
| Zirconium (40)  | Zr-95   |   | 6X10 <sup>-4</sup>  |
|   | Zr-97   |   | 2X10 <sup>-4</sup>  |
| Beta and/or gamma emitting radioactive material not listed above with half-life less than 3 years |         | 1X10 <sup>-10</sup>                       | 1X10 <sup>-6</sup>  |

1/ Values are given in Column I only for those materials normally used as gases.  
 2/ μCi/gm for solids.

NOTE 1: Many radioisotopes disintegrate into isotopes, which are also radioactive. In expressing the concentrations in Schedule A the activity stated is that of the parent isotope and takes into account the daughters.

NOTE 2: For purposes of Part C. where there is involved a combination of isotopes, the limit for the combination should be derived as follows: Determine for each isotope in the product the ratio between the radioactivity concentration present in the product and the exempt radioactivity concentration established in Schedule A for the specific isotope when not in combination. The sum of such ratios may not exceed "1" (i.e., unity).

**EXAMPLE:**

$$\frac{\text{Concentration of Isotope A in Product}}{\text{Exempt concentration of Isotope A}} +$$

$$\frac{\text{Concentration of Isotope B in Product}}{\text{Exempt concentration of Isotope B}} = 1$$

NOTE 3: To convert μCi/ml to SI units of megabecquerels per liter multiply the above values by 37.

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## SCHEDULE B

### EXEMPT QUANTITIES OF INDIVIDUAL RADIOACTIVE MATERIALS (C.3.B)

| Radioactive Material       | MicroCuries | Radioactive Material   | MicroCuries |
|----------------------------|-------------|------------------------|-------------|
| Antimony-122 (Sb 122)      | 100         | Gallium-67 (Ga 67)     | 100         |
| Antimony-124 (Sb 124)      | 10          | Gallium-72 (Ga 72)     | 10          |
| Antimony-125 (Sb 125)      | 10          | Germanium-68 (Ge 68)   | 10          |
| Arsenic-73 (As 73)         | 100         | Germanium-71 (Ge 71)   | 100         |
| Arsenic-74 (As 74)         | 10          | Gold-195 (Au 195)      | 10          |
| Arsenic-76 (As 76)         | 10          | Gold-198 (Au 198)      | 100         |
| Arsenic-77 (As 77)         | 100         | Gold-199 (Au 199)      | 100         |
| Barium-131 (Ba 131)        | 10          | Hafnium-181 (Hf 181)   | 10          |
| Barium-133 (Ba 133)        | 10          | Holmium-166 (Ho 166)   | 100         |
| Barium-140 (Ba 140)        | 10          | Hydrogen-3 (H 3)       | 1,000       |
| Bismuth-210 (Bi 210)       | 1           | Indium-111 (In 111)    | 100         |
| Bromine-82 (Br 82)         | 10          | Indium-113m (In 113m)  | 100         |
| Cadmium-109 (Cd 109)       | 10          | Indium-114m (In 114m)  | 10          |
| Cadmium-115m (Cd 115m)     | 10          | Indium-115m (In 115m)  | 100         |
| Cadmium-115 (Cd 115)       | 100         | Indium-115 (In 115)    | 10          |
| Calcium-45 (Ca 45)         | 10          | Iodine-123 (I 123)     | 100         |
| Calcium-47 (Ca 47)         | 10          | Iodine-125 (I 125)     | 1           |
| Carbon-14 (C 14)           | 100         | Iodine-126 (I 126)     | 1           |
| Cerium-141 (Ce 141)        | 100         | Iodine-129 (I 129)     | 0.1         |
| Cerium-143 (Ce 143)        | 100         | Iodine-131 (I 131)     | 1           |
| Cerium-144 (Ce 144)        | 1           | Iodine-132 (I 132)     | 10          |
| Cesium-129 (Cs 129)        | 100         | Iodine-133 (I 133)     | 1           |
| Cesium-131 (Cs 131)        | 1,000       | Iodine-134 (I 134)     | 10          |
| Cesium-134m (Cs 134m)      | 100         | Iodine-135 (I 135)     | 10          |
| Cesium-134 (Cs 134)        | 1           | Iridium-192 (Ir 192)   | 10          |
| Cesium-135 (Cs 135)        | 10          | Iridium-194 (Ir 194)   | 100         |
| Cesium-136 (Cs 136)        | 10          | Iron-52 (Fe 52)        | 10          |
| Cesium-137 (Cs 137)        | 10          | Iron-55 (Fe 55)        | 100         |
| Chlorine-36 (Cl 36)        | 10          | Iron-59 (Fe 59)        | 10          |
| Chlorine-38 (Cl 38)        | 10          | Krypton-85 (Kr 85)     | 100         |
| Chromium-51 (Cr 51)        | 1,000       | Krypton-87 (Kr 87)     | 10          |
| Cobalt-57 (Co 57)          | 100         | Lanthanum-140 (La 140) | 10          |
| Cobalt-58m (Co 58m)        | 10          | Lutetium-177 (Lu 177)  | 100         |
| Cobalt-58 (Co 58)          | 10          | Manganese-52 (Mn 52)   | 10          |
| Cobalt-60 (Co 60)          | 1           | Manganese-54 (Mn 54)   | 10          |
| Copper-64 (Cu 64)          | 100         | Manganese-56 (Mn 56)   | 10          |
| Dysprosium-165 (Dy 165)    | 10          | Mercury-197m (Hg 197m) | 100         |
| Dysprosium-166 (Dy 166)    | 100         | Mercury-197 (Hg 197)   | 100         |
| Erbium-169 (Er 169)        | 100         | Mercury-203 (Hg 203)   | 10          |
| Erbium-171 (Er 171)        | 100         | Molybdenum-99 (Mo 99)  | 100         |
| Europium-152 (Eu 152) 9.2h | 100         | Neodymium-147 (Nd 147) | 100         |
| Europium-152 (Eu 152) 13yr | 1           | Neodymium-149 (Nd 149) | 100         |
| Europium-154 (Eu 154)      | 1           | Nickel-59 (Ni 59)      | 100         |
| Europium-155 (Eu 155)      | 10          | Nickel-63 (Ni 63)      | 10          |
| Fluorine-18 (F 18)         | 1,000       | Nickel-65 (Ni 65)      | 100         |
| Gadolinium-153 (Gd 153)    | 10          | Niobium-93m (Nb 93m)   | 10          |
| Gadolinium-159 (Gd 159)    | 100         | Niobium-95 (Nb 95)     | 10          |

C.Schedule B

| Radioactive Material    | MicroCuries | Radioactive Material                           | MicroCuries |
|-------------------------|-------------|--|-------------|
| Niobium-97 (Nb 97)      | 10          | Strontium 92 (Sr 92)                           | 10          |
| Osmium-185 (Os 185)     | 10          | Sulphur-35 (S 35)                              | 100         |
| Osmium-191m (Os 191m)   | 100         | Tantalum-182 (Ta 182)                          | 10          |
| Osmium-191 (Os 191)     | 100         | Technetium-96 (Tc 96)                          | 10          |
| Osmium-193 (Os 193)     | 100         | Technetium-97m (Tc 97m)                        | 100         |
| Palladium-103 (Pd 103)  | 100         | Technetium-97 (Tc 97)                          | 100         |
| Palladium-109 (Pd 109)  | 100         | Technetium-99m (Tc 99m)                        | 100         |
| Phosphorus-32 (P 32)    | 10          | Technetium-99 (Tc 99)                          | 10          |
| Platinum-191 (Pt 191)   | 100         | Tellurium-125m (Te 125m)                       | 10          |
| Platinum-193m (Pt 193m) | 100         | Tellurium-127m (Te 127m)                       | 10          |
| Platinum-193 (Pt 193)   | 100         | Tellurium-127 (Te 127)                         | 100         |
| Platinum-197m (Pt 197m) | 100         | Tellurium-129m (Te 129m)                       | 10          |
| Platinum-197 (Pt 197)   | 100         | Tellurium-129 (Te 129)                         | 100         |
| Polonium-210 (Po 210)   | 0.1         | Tellurium-131m (Te 131m)                       | 10          |
| Potassium-42 (K 42)     | 10          | Tellurium-132 (Te 132)                         | 10          |
| Potassium-43 (K 43)     | 10          | Terbium-160 (Tb 160)                           | 10          |
| Praseodymium-142(Pr142) | 100         | Thallium-200 (Tl 200)                          | 100         |
| Praseodymium-143(Pr143) | 100         | Thallium-201 (Tl 201)                          | 100         |
| Promethium-147 (Pm 147) | 10          | Thallium-202 (Tl 202)                          | 100         |
| Promethium-149 (Pm 149) | 10          | Thallium-204 (Tl 204)                          | 10          |
| Rhenium-186 (Re 186)    | 100         | Thulium-170 (Tm 170)                           | 10          |
| Rhenium-188 (Re 188)    | 100         | Thulium-171 (Tm 171)                           | 10          |
| Rhodium-103m (Rh 103m)  | 100         | Tin-113 (Sn 113)                               | 10          |
| Rhodium-105 (Rh 105)    | 100         | Tin-125 (Sn 125)                               | 10          |
| Rubidium-81 (Rb 81)     | 10          | Tungsten-181 (W 181)                           | 10          |
| Rubidium-86 (Rb 86)     | 10          | Tungsten-185 (W 185)                           | 10          |
| Rubidium-87 (Rb 87)     | 10          | Tungsten-187 (W 187)                           | 100         |
| Ruthenium-97 (Ru 97)    | 100         | Vanadium-48 (V 48)                             | 10          |
| Ruthenium-103 (Ru 103)  | 10          | Xenon-131m (Xe 131m)                           | 1,000       |
| Ruthenium-105 (Ru 105)  | 10          | Xenon-133 (Xe 133)                             | 100         |
| Ruthenium-106 (Ru 106)  | 1           | Xenon-135 (Xe 135)                             | 100         |
| Samarium-151 (Sm 151)   | 10          | Ytterbium-175 (Yb 175)                         | 100         |
| Samarium-153 (Sm 153)   | 100         | Yttrium-87 (Y 87)                              | 10          |
| Scandium-46 (Sc 46)     | 10          | Yttrium-88 (Y 88)                              | 10          |
| Scandium-47 (Sc 47)     | 100         | Yttrium-90 (Y 90)                              | 10          |
| Scandium-48 (Sc 48)     | 10          | Yttrium-91 (Y 91)                              | 10          |
| Selenium-75 (Se 75)     | 10          | Yttrium-92 (Y 92)                              | 100         |
| Silicon-31 (Si 31)      | 100         | Yttrium-93 (Y 93)                              | 100         |
| Silver-105 (Ag 105)     | 10          | Zinc-65 (Zn 65)                                | 10          |
| Silver-110m (Ag 110m)   | 1           | Zinc-69m (Zn 69m)                              | 100         |
| Silver-111 (Ag 111)     | 100         | Zinc-69 (Zn 69)                                | 1,000       |
| Sodium-22 (Na 22)       | 10          | Zirconium-93 (Zr 93)                           | 10          |
| Sodium-24 (Na 24)       | 10          | Zirconium-95 (Zr 95)                           | 10          |
| Strontium-85 (Sr 85)    | 10          | Zirconium-97 (Zr 97)                           | 10          |
| Strontium-89 (Sr 89)    | 1           |  |             |
| Strontium 90 (Sr 90)    | 0.1         | Any radioactive material not listed above      |             |
| Strontium 91 (Sr 91)    | 10          | other than alpha emitting radioactive material | 0.1         |

NOTE: To convert microcuries ( $\mu\text{Ci}$ ) to SI units of kilobecquerels (kBq), multiply the above by 37.

## SCHEDULE C

### LIMITS FOR BROAD LICENSES (C.10)

| Radioactive Material | Col I*<br>Curies | Col II**<br>Curies | Radioactive Material | Col I*<br>Curies | Col II**<br>Curies |
|----------------------|------------------|--------------------|----------------------|------------------|--------------------|
| Antimony-122         | 1                | 0.01               | Gallium-72           | 10               | 0.1                |
| Antimony-124         | 1                | 0.01               | Germanium-71         | 100              | 1                  |
| Antimony-125         | 1                | 0.01               | Gold-198             | 10               | 0.1                |
| Arsenic-73           | 10               | 0.1                | Gold-199             | 10               | 0.1                |
| Arsenic-74           | 1                | 0.01               | Hafnium-181          | 1                | 0.01               |
| Arsenic-76           | 1                | 0.01               | Holmium-166          | 10               | 0.1                |
| Arsenic-77           | 10               | 0.1                | Hydrogen-3           | 100              | 1                  |
| Barium-131           | 10               | 0.1                | Indium-113m          | 100              | 1                  |
| Barium-140           | 1                | 0.01               | Indium-114m          | 1                | 0.01               |
| Beryllium-7          | 10               | 0.1                | Indium-115m          | 100              | 1                  |
| Bismuth-210          | 0.1              | 0.001              | Indium-115           | 1                | 0.01               |
| Bromine-82           | 10               | 0.1                | Iodine-125           | 0.1              | 0.001              |
| Cadmium-109          | 1                | 0.01               | Iodine-126           | 0.1              | 0.001              |
| Cadmium-115m         | 1                | 0.01               | Iodine-129           | 0.1              | 0.001              |
| Cadmium-115          | 10               | 0.1                | Iodine-131           | 0.1              | 0.001              |
| Calcium-45           | 1                | 0.01               | Iodine-132           | 10               | 0.1                |
| Calcium-47           | 10               | 0.1                | Iodine-133           | 1                | 0.01               |
| Carbon-14            | 100              | 1                  | Iodine-134           | 10               | 0.1                |
| Cerium-141           | 10               | 0.1                | Iodine-135           | 1                | 0.01               |
| Cerium-143           | 10               | 0.1                | Iridium-192          | 1                | 0.01               |
| Cerium-144           | 0.1              | 0.001              | Iridium-194          | 10               | 0.1                |
| Cesium-131           | 100              | 1                  | Iron-55              | 10               | 0.1                |
| Cesium-134m          | 100              | 1                  | Iron-59              | 1                | 0.01               |
| Cesium-134           | 0.1              | 0.001              | Krypton-85           | 100              | 1                  |
| Cesium-135           | 1                | 0.01               | Krypton-87           | 10               | 0.1                |
| Cesium-136           | 10               | 0.1                | Lanthanum-140        | 1                | 0.01               |
| Cesium-137           | 0.1              | 0.001              | Lutetium-177         | 10               | 0.1                |
| Chlorine-36          | 1                | 0.01               | Manganese-52         | 1                | 0.01               |
| Chlorine-38          | 100              | 1                  | Manganese-54         | 1                | 0.01               |
| Chromium-51          | 100              | 1                  | Manganese-56         | 10               | 0.1                |
| Cobalt-57            | 10               | 0.1                | Mercury-197m         | 10               | 0.1                |
| Cobalt-58m           | 100              | 1                  | Mercury-197          | 10               | 0.1                |
| Cobalt-58            | 1                | 0.01               | Mercury-203          | 1                | 0.01               |
| Cobalt-60            | 0.1              | 0.001              | Molybdenum-99        | 10               | 0.1                |
| Copper-64            | 10               | 0.1                | Neodymium-147        | 10               | 0.1                |
| Dysprosium-165       | 100              | 1                  | Neodymium-149        | 10               | 0.1                |
| Dysprosium-166       | 10               | 0.1                | Nickel-59            | 10               | 0.1                |
| Erbium-169           | 10               | 0.1                | Nickel-63            | 1                | 0.01               |
| Erbium-171           | 10               | 0.1                | Nickel-65            | 10               | 0.1                |
| Europium-152(9.2h)   | 10               | 0.1                | Niobium-93m          | 1                | 0.01               |
| Europium-152(13y)    | 0.1              | 0.001              | Niobium-95           | 1                | 0.01               |
| Europium-154         | 0.1              | 0.001              | Niobium-97           | 100              | 1                  |
| Europium-155         | 1                | 0.01               | Osmium-185           | 1                | 0.01               |
| Fluorine-18          | 100              | 1                  | Osmium-191m          | 100              | 1                  |
| Gadolinium-153       | 1                | 0.01               | Osmium-191           | 10               | 0.1                |
| Gadolinium-159       | 10               | 0.1                | Osmium-193           | 10               | 0.1                |

\* Type B Specific license \*\* Type C Specific license

C. SCHEDULE C

| Radioactive Material | Col I*<br>Curies | Col II**<br>Curies | Radioactive Material  | Col I*<br>Curies | Col II**<br>Curies |
|----------------------|------------------|--------------------|---|------------------|--------------------|
| Palladium-103        | 10               | 0.1                | Technetium-96   | 10               | 0.1                |
| Palladium-109        | 10               | 0.1                | Technetium-97m  | 10               | 0.1                |
| Phosphorus-32        | 1                | 0.01               | Technetium-97   | 10               | 0.1                |
| Platinum-191         | 10               | 0.1                | Technetium-99m  | 100              | 1                  |
| Platinum-193m        | 100              | 1                  | Technetium-99   | 1                | 0.01               |
| Platinum-193         | 10               | 0.1                | Tellurium-125m  | 1                | 0.01               |
| Platinum 197m        | 100              | 1                  | Tellurium-127m  | 1                | 0.01               |
| Platinum-197         | 10               | 0.1                | Tellurium-127   | 10               | 0.1                |
| Polonium-210         | 0.01             | 0.0001             | Tellurium-129m  | 1                | 0.01               |
| Potassium-42         | 1                | 0.01               | Tellurium-129   | 100              | 1                  |
| Praseodymium-142     | 10               | 0.1                | Tellurium-131m  | 10               | 0.1                |
| Praseodymium-143     | 10               | 0.1                | Tellurium-132   | 1                | 0.01               |
| Promethium-147       | 1                | 0.01               | Terbium-160   | 1                | 0.01               |
| Promethium-149       | 10               | 0.1                | Thallium-200  | 10               | 0.1                |
| Radium-226           | 0.01             | 0.0001             | Thallium-201  | 10               | 0.1                |
| Rhenium-186          | 10               | 0.1                | Thallium-202  | 10               | 0.1                |
| Rhenium-188          | 10               | 0.1                | Thallium-204  | 1                | 0.01               |
| Rhodium-103m         | 1,000            | 10                 | Thulium-170   | 1                | 0.01               |
| Rhodium-105          | 10               | 0.1                | Thulium-171   | 1                | 0.01               |
| Rubidium-86          | 1                | 0.01               | Tin-113   | 1                | 0.01               |
| Rubidium-87          | 1                | 0.01               | Tin-125   | 1                | 0.01               |
| Ruthenium-97         | 100              | 1                  | Tungsten-181  | 1                | 0.01               |
| Ruthenium-103        | 1                | 0.01               | Tungsten-185  | 1                | 0.01               |
| Ruthenium-105        | 10               | 0.1                | Tungsten-187  | 10               | 0.1                |
| Ruthenium-106        | 0.1              | 0.001              | Vanadium-48   | 1                | 0.01               |
| Samarium-151         | 1                | 0.01               | Xenon-131m  | 1,000            | 10                 |
| Samarium-153         | 10               | 0.1                | Xenon-133   | 100              | 1                  |
| Scandium-46          | 1                | 0.01               | Xenon-135   | 100              | 1                  |
| Scandium-47          | 10               | 0.1                | Ytterbium-175   | 10               | 0.1                |
| Scandium-48          | 1                | 0.01               | Yttrium-90  | 1                | 0.01               |
| Selenium-75          | 1                | 0.01               | Yttrium-91  | 1                | 0.01               |
| Silicon-31           | 10               | 0.1                | Yttrium-92  | 10               | 0.1                |
| Silver-105           | 1                | 0.01               | Yttrium-93  | 1                | 0.01               |
| Silver-110m          | 0.1              | 0.001              | Zinc-65   | 1                | 0.01               |
| Silver-111           | 10               | 0.1                | Zinc-69m  | 10               | 0.1                |
| Sodium-22            | 0.1              | 0.001              | Zinc-69   | 100              | 1                  |
| Sodium-24            | 1                | 0.01               | Zirconium-93  | 1                | 0.01               |
| Strontium-85m        | 1,000            | 10                 | Zirconium-95  | 1                | 0.01               |
| Strontium-85         | 1                | 0.01               | Zirconium-97  | 1                | 0.01               |
| Strontium-89         | 1                | 0.01               | Any radioactive material other than source material, special nuclear material, or alpha emitting radioactive material not listed above. | 0.1              | 0.001              |
| Strontium-90         | 0.01             | 0.0001             |   |                  |                    |
| Strontium-91         | 10               | 0.1                |   |                  |                    |
| Strontium-92         | 10               | 0.1                |   |                  |                    |
| Sulphur-35           | 10               | 0.1                |   |                  |                    |
| Tantalum-182         | 1                | 0.01               |   |                  |                    |

\* Type B Specific license \*\* Type C Specific license

NOTE 1: To convert curies (Ci) to SI units of gigabecquerels (GBq), multiply the above values by 37.

## SCHEDULE D

### QUANTITIES OF RADIOACTIVE MATERIALS REQUIRING CONSIDERATION OF THE NEED FOR AN EMERGENCY PLAN FOR RESPONDING TO A RELEASE

| Radioactive Material <sup>1</sup> | Release Fraction | Quantity (curies) | Radioactive Material | Release Fraction | Quantity (curies) |
|-----------------------------------|------------------|-------------------|----------------------|------------------|-------------------|
| Actinium-228                      | 0.001            | 4,000             | Indium-114m          | 0.01             | 1,000             |
| Americium-241                     | 0.001            | 2                 | Iodine-125           | 0.5              | 10                |
| Americium-242                     | 0.001            | 2                 | Iodine-131           | 0.5              | 10                |
| Americium-243                     | 0.001            | 2                 | Iridium-192          | 0.001            | 40,000            |
| Antimony-124                      | 0.01             | 4,000             | Iron-55              | 0.01             | 40,000            |
| Antimony-126                      | 0.01             | 6,000             | Iron-59              | 0.01             | 7,000             |
| Barium-133                        | 0.01             | 10,000            | Krypton-85           | 1                | 6,000,000         |
| Barium-140                        | 0.01             | 30,000            | Lead-210             | 0.01             | 8                 |
| Bismuth-207                       | 0.01             | 5,000             | Manganese-56         | 0.01             | 60,000            |
| Bismuth-210                       | 0.01             | 600               | Mercury-203          | 0.01             | 10,000            |
| Cadmium-109                       | 0.01             | 1,000             | Molybdenum-99        | 0.01             | 30,000            |
| Cadmium-113                       | 0.01             | 80                | Neptunium-237        | 0.001            | 2                 |
| Calcium-45                        | 0.01             | 20,000            | Nickel-63            | 0.01             | 20,000            |
| Californium-252                   | 0.001            | 9 (20 mg)         | Niobium-94           | 0.01             | 300               |
| Carbon-14 (NonCO <sub>2</sub> )   | 0.01             | 50,000            | Phosphorus-32        | 0.5              | 100               |
| Cerium-141                        | 0.01             | 10,000            | Phosphorus-33        | 0.5              | 1,000             |
| Cerium-144                        | 0.01             | 300               | Polonium-210         | 0.01             | 10                |
| Cesium-134                        | 0.01             | 2,000             | Potassium-42         | 0.01             | 9,000             |
| Cesium-137                        | 0.01             | 3,000             | Promethium-145       | 0.01             | 4,000             |
| Chlorine-36                       | 0.5              | 100               | Promethium-147       | 0.01             | 4,000             |
| Chromium-51                       | 0.01             | 300,000           | Ruthenium-106        | 0.01             | 200               |
| Cobalt-60                         | 0.001            | 5,000             | Samarium-151         | 0.01             | 4,000             |
| Copper-64                         | 0.01             | 200,000           | Scandium-46          | 0.01             | 3,000             |
| Curium-242                        | 0.001            | 60                | Selenium-75          | 0.01             | 10,000            |
| Curium-243                        | 0.001            | 3                 | Silver-110m          | 0.01             | 1,000             |
| Curium-244                        | 0.001            | 4                 | Sodium-22            | 0.01             | 9,000             |
| Curium-245                        | 0.001            | 2                 | Sodium-24            | 0.01             | 10,000            |
| Europium-152                      | 0.01             | 500               | Strontium-89         | 0.01             | 3,000             |
| Europium-154                      | 0.01             | 400               | Strontium-90         | 0.01             | 90                |
| Europium-155                      | 0.01             | 3,000             | Sulphur-35           | 0.5              | 900               |
| Gadolinium-153                    | 0.01             | 5,000             | Technetium-99        | 0.01             | 10,000            |
| Germanium-68                      | 0.01             | 2,000             | Technetium-99m       | 0.01             | 400,000           |
| Gold-198                          | 0.01             | 30,000            | Tellurium-127m       | 0.01             | 5,000             |
| Hafnium-172                       | 0.01             | 400               | Tellurium-129m       | 0.01             | 5,000             |
| Hafnium-181                       | 0.01             | 7,000             | Terbium-160          | 0.01             | 4,000             |
| Holmium-166m                      | 0.01             | 100               | Thulium-170          | 0.01             | 4,000             |
| Hydrogen-3                        | 0.5              | 20,000            | Tin-113              | 0.01             | 10,000            |

C.Schedule D

| Radioactive Material <sup>1</sup> | Release Fraction | Quantity (curies) | Radioactive Material   | Release Fraction | Quantity (curies) |
|-----------------------------------|------------------|-------------------|--|------------------|-------------------|
| Tin-123                           | 0.01             | 3,000             | Irradiated material, any form other than solid noncombustible    | 0.01             | 1,000             |
| Tin-126                           | 0.01             | 1,000             |  |                  |                   |
| Titanium-44                       | 0.01             | 100               |  |                  |                   |
| Vanadium-48                       | 0.01             | 7,000             | Irradiated material, solid noncombustible                        | 0.001            | 10,000            |
| Xenon-133                         | 1                | 900,000           | Mixed radioactive waste, beta-gamma <sup>2/</sup>                | 0.01             | 1,000             |
| Yttrium-91                        | 0.01             | 2,000             |  |                  |                   |
| Zinc-65                           | 0.01             | 5,000             | Packaged mixed waste, beta-gamma                                 | 0.001            | 10,000            |
| Zirconium-93                      | 0.01             | 400               | Any other alpha emitter  | 0.001            | 2                 |
| Zirconium-95                      | 0.01             | 5,000             | Contaminated equipment alpha                                     | 0.0001           | 20                |
| Any other beta-gamma emitter      | 0.01             | 10,000            | Packaged waste, alpha <sup>2/</sup>                              | 0.0001           | 20                |
|                                   |                  |                   | Combinations of radioactive materials listed above <sup>1/</sup> |                  |                   |
| Mixed fission products            | 0.01             | 1,000             |  |                  |                   |
| Mixed corrosion products          | 0.01             | 10,000            |  |                  |                   |
| Contaminated equipment beta-gamma | 0.001            | 10,000            |  |                  |                   |
|                                   |                  |                   |  |                  |                   |

1/ For combinations of radioactive materials, consideration of the need for an emergency plan is required if the sum of the ratios of the quantity of each radioactive material authorized to the quantity listed for that material in schedule C exceeds one.

2/ Waste packaged in Type B containers does not require an emergency plan.

## APPENDIX A

### GENERAL PROVISIONS

#### A. Purpose.

The regulations in this part set out fees charged for licensing services rendered by the State of Maine, Radiation Control Program (the Agency), as authorized under 22 MRSA Section 690 of Maine's Radiation Protection Act.

#### B. Scope.

Except for persons who apply for or hold the permits, licenses, or approvals exempted in Part C, the regulations in this section apply to a person who is:

1. An applicant for or holder of a specific byproduct material license, NARM material, source material, or special nuclear material license issued pursuant to Part C of these rules;
2. An applicant for or holder of specific approval of shipping containers issued pursuant to Part L of these rules;
3. An applicant for or holder of a specific approval of sealed sources and devices containing byproduct material, NARM material, source material, or special nuclear material;
4. Required to have routine and non-routine safety and safeguards inspections of activities licensed pursuant to the requirements of these rules; or
5. An applicant for or holder of a license, approval, determination, or other authorization issued by the Agency pursuant to Parts D.22 and D.25 of these rules.
6. An applicant for or holder of a general license established by any of Parts C.5.E, C.6.B, or C.6.F of these rules.

#### C. Definitions.

As used in this part:

1. "Materials license" means a byproduct, NARM, or a source material license issued pursuant to Part C of these rules.
2. "Sealed source" means any byproduct material, or NARM material that is encased in a capsule designed to prevent leakage or escape of the material.
3. "Inspection" means:
  - (a) Routine inspections designed to evaluate the licensee's activities within the context of the licensee having primary responsibility for protection of the public and environment.
  - (b) Non-routine inspections in response or reaction to an incident, allegation, follow-up to inspection deficiencies or inspections to determine implementation of safety issues. A non-routine or reactive inspection has the same purpose as the routine inspection.
4. "State agency" means any executive department, commission, independent establishment, corporation, wholly or partly owned by the State of Maine, or any board, bureau, division, service, office, officer, authority, administration, or other establishment in the executive branch of the State.

**D. Exemptions.**

1. No application fees, annual fees, amendment fees, or inspection fees shall be required for:
  - (a) A license authorizing the export only of a production or utilization facility.
  - (b) A license authorizing the export only or import only of byproduct material, source material or special nuclear material.
2. A license authorizing the use of source material as shielding only in devices and containers, provided, however, that all other licensed byproduct material, source material, or special nuclear material in the device or container will be subject to the fees prescribed in Table 1 of this appendix.

**E. Payment of fees.**

1. Application fees. Each application for which a fee is prescribed shall be accompanied by a remittance in the full amount of the fee. No application will be accepted for filing or processed prior to payment of the full amount specified. Applications for which no remittance is received may be returned to the applicant. All application fees will be charged irrespective of the Agency's disposition of the application or withdrawal of the application.
2. Full cost. For each application on which the review charges are based on full costs and the application has been pending with the Agency for six months or longer, the first bill for accumulated costs will be sent and will include all of the applicable review time and contractual costs expended. Thereafter, each applicant will be billed at six-month intervals or when the review is completed, whichever is earlier. Each bill will identify the applications and the costs related to each.
3. Non-routine inspection fees. Non-routine inspection fees are payable upon notification by the Agency. Inspection costs will include preparation time, time on site and documentation time and any associated contractual service costs but will exclude the time involved by the staff in the processing and issuance of a notice of violation or civil penalty.
4. Annual fees. A license fee based upon the type of license, number of sources and/or gauges shall be assessed on an annual basis. The licensee has sixty (60) days from the postmark date of the Radioactive Materials License Annual Fees Invoice notice to submit payment in full unless special arrangements are made with the Agency. Failure to pay the annual fee by the due date will result in a penalty not to exceed 9% of the unpaid fee compounded monthly. Failure to remit full payment within six (6) months could, at the Agency's discretion, result in the initiation of license termination procedures.
5. Method of payment. Fee payments shall be by check, draft, or money order made payable to the Treasurer, State of Maine.

**F. Average cost per professional staff-hour.**

Fees for permits, licenses, amendments, renewals, special projects and inspections will be calculated based upon the full costs for the review.

TABLE 1 to Appendix A

**RADIOACTIVE MATERIALS SPECIFIC LICENSE AND INSPECTION FEE SCHEDULE**

| LICENSE CATEGORY  | APPLICATION | ANNUAL                | NON-ROUTINE INSPECTION |
|---|-------------|-----------------------|------------------------|
| <b>1. Special Nuclear Material</b>                          |             |                       |                        |
| A. Sealed sources in devices                                | \$500.00    | \$500.00 <sup>5</sup> | \$1,300.00             |
| B. Pacemakers   | \$500.00    | \$350.00              | \$800.00               |
| C. Other except critical                                    | \$690.00    | \$1,000.00            | \$800.00               |
| D. Termination  | \$500.00    | Full cost             |                        |
| <b>2. Source Material</b>                                   |             |                       |                        |
| A. Shielding  | \$110.00    | \$350.00              | \$350.00               |
| B. Other  | \$790.00    | \$1,000.00            | \$1,500.00             |
| C. Termination  | \$500.00    | Full cost             |                        |
| <b>3. Byproduct and NARM Material</b>                       |             |                       |                        |
| A. Processing and Manufacturing for commercial distribution |             |                       |                        |
| 1. Broad A  | \$2,300.00  | \$3,000.00            | \$2,100.00             |
| 2. Broad B  | \$2,300.00  | \$3,000.00            | \$2,100.00             |
| 3. Broad C  | \$2,300.00  | \$3,000.00            | \$2,100.00             |
| 4. Other  | \$1,300.00  | \$1,750.00            | \$2,000.00             |
| B. Radiopharmaceuticals, reagent kits, sources and devices  |             |                       |                        |
| 1. Proc. manu. and distribution                             | \$3,400.00  | \$2,000.00            | \$1,900.00             |
| 2. Distribution only  | \$1,100.00  | \$750.00              | \$1,200.00             |
| C. Sealed sources for irradiation                           |             |                       |                        |
| 1. Fixed, self shielded                                     | \$500.00    | \$500.00              | \$690.00               |
| 2. Exposed source < 10,000 Ci.                              | \$1,200.00  | \$1,500.00            | \$1,300.00             |
| 3. Exposed source > 10,000 Ci.                              | \$4,600.00  | \$3,000.00            | \$1,400.00             |
| D. Distribution to persons exempt (NARM)                    |             |                       |                        |
| 1. Device review required                                   | \$2,100.00  | \$750.00              | \$690.00               |
| 2. No device review required                                | \$2,600.00  | \$750.00              | \$690.00               |
| E. Distribution to persons generally licensed               |             |                       |                        |
| 1. SSD review required                                      | \$2,500.00  | \$750.00              | \$690.00               |
| 2. No SSD review required                                   | \$1,900.00  | \$750.00              | \$690.00               |
| F. Research and development, no commercial distribution     |             |                       |                        |
| 1. Broad A  | \$2,300.00  | \$1,250.00            | \$1,200.00             |
| 2. Broad B  | \$2,300.00  | \$1,000.00            | \$1,200.00             |
| 3. Broad C  | \$2,300.00  | \$750.00              | \$1,200.00             |
| 4. Other  | \$1,100.00  | \$750.00              | \$930.00               |
| G. Services for other licensees                             | \$1,400.00  | \$750.00              | \$690.00               |
| H. Industrial radiography                                   | \$3,000.00  | \$2,000.00            | \$2,500.00             |
| I. All other byproduct and NARM, except 4A through 8D       |             |                       |                        |
| 1. Portable gauges  | \$500.00    | \$500.00 <sup>5</sup> | \$1,200.00             |

C. Appendix A. Table 1

| LICENSE CATEGORY   | APPLICATION          | ANNUAL                 | NON-ROUTINE INSPECTION |
|--|----------------------|------------------------|------------------------|
| 2. Fixed gauges  | \$500.00             | \$500.00 <sup>5</sup>  | \$1,200.00             |
| 3. X-ray Fluorescence  | \$500.00             | \$500.00 <sup>5</sup>  | \$1,200.00             |
| 4. Laboratory services                                       | \$500.00             | \$350.00               | \$1,200.00             |
| 5. Storage only  | \$500.00             | \$350.00               | \$1,200.00             |
| 6. In-Vitro laboratories                                     | \$500.00             | \$500.00               | \$1,200.00             |
| 7. Gas Chromatographs  | \$500.00             | \$350.00               | \$1,200.00             |
| 8. Other   | \$500.00             | \$500.00               | \$1,200.00             |
| <b>4. Waste Disposal Services</b>                            |                      |                        |                        |
| A. Packaging or repackaging                                  | \$2,800.00           | \$2,500.00             | \$1,600.00             |
| B. Transferal to another person                              | \$1,900.00           | \$1,000.00             | \$2,100.00             |
| C. Incineration or other treatment                           | \$500.00 + full cost | Full cost              |                        |
| <b>5. Well Logging</b>                                       |                      |                        |                        |
| A. Well logging and tracer studies                           | \$3,400.00           | \$1,000.00             | \$800.00               |
| B. Field flooding tracer studies                             | \$500.00 + full cost | \$1,750.00             | \$1,200.00             |
| <b>6. Nuclear Laundries</b>                                  | \$1,400.00           | \$2,000.00             | \$1,900.00             |
| <b>7. Human use</b>  |                      |                        |                        |
| A. Teletherapy Devices                                       | \$3,400.00           | \$1,750.00             | \$1,900.00             |
| B. Broad Scope   | \$2,300.00           | \$2,500.00             | \$1,800.00             |
| C. Other Human Use   |                      |                        |                        |
| 1. G.100 authorization                                       | \$710.00             | \$750.00               | \$1,500.00             |
| 2. G.200 authorization                                       | \$710.00             | \$1000.00 <sup>6</sup> | \$1,500.00             |
| 3. G.300 authorization                                       | \$710.00             | \$1000.00 <sup>6</sup> | \$1,500.00             |
| 4. G.400 authorization                                       | \$710.00             | \$1000.00 <sup>6</sup> | \$1,500.00             |
| 5. G.500 authorization                                       | \$710.00             | \$500.00               | \$1,500.00             |
| 6. Mobile Nuclear Van  | \$710.00             | \$1,200.00             | \$1,500.00             |
| 7. HDR Brachytherapy   | \$710.00             | \$1,750.00             | \$1,900.00             |
| 8. Gamma Knife Devices                                       | \$710.00             | \$1,750.00             | \$1,900.00             |
| <b>8. Civil Defense Activities</b>                           | \$580.00             | \$350.00               | \$690.00               |
| <b>9. Device, product or sealed source safety evaluation</b> |                      |                        |                        |
| A. Devices, for commercial dist.                             | \$3,300.00           |                        |                        |
| B. Devices, single applicant                                 | \$2,000.00           |                        |                        |
| C. Sources, for commercial dist.                             | \$750.00             |                        |                        |
| D. Sources, single applicant                                 | \$750.00             |                        |                        |
| <b>10. General license registration</b>                      |                      |                        |                        |
| A. Submission of form HHE-860                                | \$100.00             | \$100.00               | \$1200.00              |
| B. Submission of form HHE-861                                | \$25.00              | \$25.00                | \$1200.00              |
| C. Submission of form HHE-862                                | \$100.00             | \$100.00               | \$1200.00              |
| D. Submission of form HHE-863                                | \$100.00             | \$100.00               | \$1200.00              |
| E. Submission of form HHE-867                                | \$100.00             | \$100.00               | \$1200.00              |

**C. Appendix A**

1. Types of material license fees - Separate charges as shown in the schedule will be assessed for applications for new licenses and approvals, issuance of new licenses and approvals, and amendments to existing licenses and approvals. The following guidelines apply to these charges:
  - (a) Application fees - Applications for materials licenses and approvals must be accompanied by the prescribed application fee for each category, except that applications for licenses covering more than one fee category of special nuclear material or source material to be used at the same location, must be accompanied by the prescribed application fee for the highest fee category. When a license or approval has expired, the application fee for each category shall be due, except for licenses covering more than one fee category of special nuclear material or source material for use at the same location, in which case the application fee for the highest category applies.
  - (b) License/approval fees - For new licenses and approvals issued in fee Categories 1D 2C, 4C, and 5B, the recipient shall pay the license or approval fee for each category, as determined by the Agency in accordance with Part E of this Appendix except that a license covering more than one fee category of special nuclear material in Categories 1A through 1D or source material in fee Categories 2A through 2C must pay a license fee for the highest fee category assigned to the license.
  - (c) Amendment fees - Applications for amendments must be accompanied by the minimum amendment fee of \$50.00. The Agency will compute the final amendment fee based upon actual costs, but not more than \$500.00, and the applicant will be billed at the completion of the licensing action.
2. Material license fees will not be charged for orders issued by the Agency pursuant to Part B.8 nor for amendments resulting specifically from such orders. However, fees will be charged for approvals issued pursuant to a specific exemption provision of the Agency's regulations regardless of whether the approval is in the form of a license amendment, letter of approval, safety evaluation report, or other form. In addition to the fee shown, an applicant may be assessed an additional fee for sealed source and device evaluations as shown in Categories 9A through 9D.
3. Types of inspections - Separate charges as shown in this schedule will be the maximum amount assessed for each non-routine inspection, which is performed. The amount that will be charged to the licensee will be based on the staff time and contractual costs expended by the agency.
4. A licensee who is authorized to use licensed radioactive materials at multiple locations that are not immediately adjacent, or on the same campus, will be assessed an additional 25% of their annual fee.
5. The following scale of additional fees will be added to the stated annual fee as applicable from the licensed quantity. If a licensee is authorized for use under fee categories 1.A, 3.I.1, and/or 3.I.3 the total number of gauges authorized under all types are cumulative. If more than one of the remaining fee categories also applies to a licensee only the highest fee will be charged.

| <b>License Categories</b> | <b>1 to 5 gauges</b>  | <b>6 to 15 gauges</b>  | <b>16 gauges plus</b> |
|---------------------------|-----------------------|------------------------|-----------------------|
| <b>1.A.</b>               | 0                     | \$250.00               | \$500.00              |
| <b>3.I.1.</b>             | 0                     | \$250.00               | \$500.00              |
| <b>3.I.3.</b>             | 0                     | \$250.00               | \$500.00              |
| <b>License Category</b>   | <b>1 to 10 gauges</b> | <b>11 to 30 gauges</b> | <b>31 gauges plus</b> |
| <b>3.I.2.</b>             | 0                     | \$250.00               | \$500.00              |

6. The license fee categories 7.C.1 through 7.C.5 will be charged the stated fee if any of the categories are authorized singly. If multiple categories are authorized an additional fee of \$250.00 per category will be added to the annual fee of the highest fee category. If any of the categories 7.C.2 through 7.C.4 are authorized then authorization for 7.C.1 will not incur an additional fee.

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## APPENDIX B

### NATURALLY OCCURRING OR ACCELERATOR PRODUCED RADIOACTIVE MATERIAL (NARM)

Examples of Naturally Occurring Radioactive Materials. (Naturally occurring radioactive material is any material of natural origin that emits radiation spontaneously, excluding uranium, thorium, and the tailings produced in their extraction)

|               |                |                   |
|---------------|----------------|-------------------|
| Hydrogen-3    | Indium-115     | Lead-210          |
| Beryllium-7   | Lanthanum-138  | Lead-212          |
| Beryllium-10  | Cerium-142     | Bismuth-210       |
| Carbon-14     | Neodymium-144  | Bismuth-212       |
| Sodium-22     | Samarium-147   | Polonium-210      |
| Silicon-32    | Samarium-148   | Radon-220         |
| Phosphorus-32 | Samarium-149   | Radon-222         |
| Phosphorus-33 | Gadolinium-152 | Radium-224        |
| Sulfur-35     | Hafnium-174    | Radium-226        |
| Chlorine-36   | Lutetium-176   | Radium-228        |
| Chlorine-39   | Rhenium-187    | Actinium-227      |
| Potassium-40  | Platinum-190   | Actinium-228      |
| Vanadium-50   | Platinum-192   | Protoactinium-231 |
| Rubidium-87   | Lead-204       |                   |

Examples of Accelerator-Produced Radioactive Materials. (Accelerator-produced radioactive material is any material made radioactive (emits radiation spontaneously) by a particle accelerator)

|               |                |                |
|---------------|----------------|----------------|
| Carbon-11     | Zinc-62        | Iodine-124     |
| Nitrogen-13   | Gallium-66     | Iodine-125*    |
| Oxygen-15     | Gallium-67     | Iodine-126     |
| Fluorine-18   | Germanium-68   | Xenon-127      |
| Sodium-22     | Arsenic-73     | Cesium-131     |
| Magnesium-28  | Selenium-73    | Promethium-145 |
| Aluminum-28   | Bromine-77     | Dysprosium-157 |
| Phosphorus-33 | Krypton-77     | Osmium-190     |
| Argon-37      | Krypton-81     | Iridium-190    |
| Potassium-43  | Rubidium-81    | Iridium-190m   |
| Scandium-49   | Rubidium-82    | Platinum-193m  |
| Manganese-52  | Rubidium-84    | Gold-195       |
| Iron-52       | Strontium-82   | Mercury-197    |
| Cobalt-57     | Strontium-87m  | Thallium-199   |
| Cobalt-58     | Yttrium-87     | Thallium-201   |
| Copper-62     | Technetium-97m | Lead-203       |
| Copper-67     | Indium-111     | Bismuth-204    |
| Zinc-62       | Iodine-123     |                |

\* Excludes Iodine-125 as byproduct material, which requires licensing by either the U.S. Nuclear Regulatory Commission or an Agreement State.

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# Appendix C

## Criteria Relating to Use of Financial Tests and Parent Company Guarantees for Providing Reasonable Assurance of Funds for Decommissioning

### A. Introduction

An applicant or licensee may provide reasonable assurance of the availability of funds for decommissioning based on obtaining a parent company guarantee that funds will be available for decommissioning costs and on a demonstration that the parent company passes a financial test. This appendix establishes criteria for passing the financial test and for obtaining the parent company guarantee.

### B. Financial Test

1. To pass the financial test, the parent company must meet the criteria of either paragraph 1.a or 2.a of this section:

a. The parent company must have:

- (1) Two of the following three ratios: A ratio of total liabilities to net worth less than 2.0; a ratio of the sum of net income plus depreciation, depletion, and amortization to total liabilities greater than 0.1; and a ratio of current assets to current liabilities greater than 1.5; and
- (2) Net working capital and tangible net worth each at least six times the current decommissioning cost estimates for the total of all facilities or parts thereof (or prescribed amount if a certification is used), or, for a power reactor licensee, at least six times the amount of decommissioning funds being assured by a parent company guarantee for the total of all reactor units or parts thereof (Tangible net worth shall be calculated to exclude the net book value of the nuclear unit(s)); and
- (3) Tangible net worth of at least \$10 million; and
- (4) Assets located in the United States amounting to at least 90 percent of the total assets or at least six times the current decommissioning cost estimates for the total of all facilities or parts thereof (or prescribed amount if a certification is used), or, for a power reactor licensee, at least six times the amount of decommissioning funds being assured by a parent company guarantee for the total of all reactor units or parts thereof.

b. The parent company must have:

- (1) A current rating for its most recent bond issuance of AAA, AA, A, or BBB as issued by Standard and Poor's or AAA, AA, A, or BAA as issued by Moody's; and
- (2) Tangible net worth each at least six times the current decommissioning cost estimates for the total of all facilities or parts thereof (or prescribed amount if a certification is used), or, for a power reactor licensee, at least six times the amount of decommissioning funds being assured by a parent company guarantee for the total of all reactor units or parts thereof (Tangible net worth shall be calculated to exclude the net book value of the nuclear unit(s)); and
- (3) Tangible net worth of at least \$10 million; and
- (4) Assets located in the United States amounting to at least 90 percent of the total assets or at least six times the current decommissioning cost estimates for the total of all facilities or parts thereof (or prescribed amount if a certification is used), or, for a power reactor licensee, at least six times the amount of decommissioning funds being assured by a parent company guarantee for the total of all reactor units or parts thereof.

## **C. Appendix C.**

2. The parent company's independent certified public accountant must have compared the data used by the parent company in the financial test, which is derived from the independently audited, year end financial statements for the latest fiscal year, with the amounts in such financial statement. In connection with that procedure the licensee shall inform the Agency within 90 days of any matters coming to the auditor's attention which cause the auditor to believe that the data specified in the financial test should be adjusted and that the company no longer passes the test.
3. a. After the initial financial test, the parent company must repeat the passage of the test within 90 days after the close of each succeeding fiscal year.
  - b. If the parent company no longer meets the requirements of paragraph A of this section, the licensee must send notice to the Agency of intent to establish alternate financial assurance as specified in the Agency's regulations. The notice must be sent by certified mail within 90 days after the end of the fiscal year for which the year end financial data show that the parent company no longer meets the financial test requirements. The licensee must provide alternate financial assurance within 120 days after the end of such fiscal year.

### **C. Parent Company Guarantee**

The terms of a parent company guarantee which an applicant or licensee obtains must provide that:

1. The parent company guarantee will remain in force unless the guarantor sends notice of cancellation by certified mail to the licensee and the Agency. Cancellation may not occur, however, during the 120 days beginning on the date of receipt of the notice of cancellation by both the licensee and the Agency, as evidenced by the return receipts.
2. If the licensee fails to provide alternate financial assurance as specified in the Agency's regulations within 90 days after receipt by the licensee and Agency of a notice of cancellation of the parent company guarantee from the guarantor, the guarantor will provide such alternative financial assurance in the name of the licensee.
3. The parent company guarantee and financial test provisions must remain in effect until the Agency has terminated the license.
4. If a trust is established for decommissioning costs, the trustee and trust must be acceptable to the Agency. An acceptable trustee includes an appropriate State or Federal Government agency or an entity which has the authority to act as a trustee and whose trust operations are regulated and examined by a Federal or State agency.

## Appendix D

### Criteria Relating to Use of Financial Tests and Self Guarantees for Providing Reasonable Assurance of Funds for Decommissioning

#### A. Introduction

An applicant or licensee may provide reasonable assurance of the availability of funds for decommissioning based on furnishing its own guarantee that funds will be available for decommissioning costs and on a demonstration that the company passes the financial test of Section B of this appendix. The terms of the self-guarantee are in Section C of this appendix. This appendix establishes criteria for passing the financial test for the self guarantee and establishes the terms for a self-guarantee.

#### B. Financial Test

1. To pass the financial test, a company must meet all of the following criteria:
  - a. Tangible net worth at least 10 times the total current decommissioning cost estimate for the total of all facilities or parts thereof (or the current amount required if certification is used), or, for a power reactor licensee, at least 10 times the amount of decommissioning funds being assured by a self guarantee, for all decommissioning activities for which the company is responsible as self-guaranteeing licensee and as parent-guarantor for the total of all reactor units or parts thereof (Tangible net worth shall be calculated to exclude the net book value of the nuclear unit(s)).
  - b. Assets located in the United States amounting to at least 90 percent of total assets or at least 10 times the total current decommissioning cost estimate for the total of all facilities or parts thereof (or the current amount required if certification is used), or, for a power reactor licensee, at least 10 times the amount of decommissioning funds being assured by a self guarantee, for all decommissioning activities for which the company is responsible as self-guaranteeing licensee and as parent-guarantor for the total of all reactor units or parts thereof.
  - c. A current rating for its most recent bond issuance of AAA, AA, or A as issued by Standard and Poors (S&P), or Aaa, Aa, or A as issued by Moodys.
2. To pass the financial test, a company must meet all of the following additional requirements:
  - a. The company must have at least one class of equity securities registered under the Securities Exchange Act of 1934.
  - b. The company's independent certified public accountant must have compared the data used by the company in the financial test, which is derived from the independently audited, yearend financial statements for the latest fiscal year, with the amounts in such financial statement. In connection with that procedure, the licensee shall inform the Agency within 90 days of any matters coming to the attention of the auditor that cause the auditor to believe that the data specified in the financial test should be adjusted and that the company no longer passes the test.
  - c. After the initial financial test, the company must repeat passage of the test within 90 days after the close of each succeeding fiscal year.
3. If the licensee no longer meets the requirements of Section B.2. of this appendix, the licensee must send immediate notice to the Agency of its intent to establish alternate financial assurance as specified in the Agency's regulations within 120 days of such notice.

**C. Company Self-Guarantee**

The terms of a self-guarantee which an applicant or licensee furnishes must provide that:

1. The guarantee will remain in force unless the licensee sends notice of cancellation by certified mail to the Agency. Cancellation may not occur, however, during the 120 days beginning on the date of receipt of the notice of cancellation by the Agency, as evidenced by the return receipt.
2. The licensee shall provide alternative financial assurance as specified in the Agency's regulations within 90 days following receipt by the Agency of a notice of cancellation of the guarantee.
3. The guarantee and financial test provisions must remain in effect until the Agency has terminated the license or until another financial assurance method acceptable to the Agency has been put in effect by the licensee.
4. The licensee will promptly forward to the Agency and the licensee's independent auditor all reports covering the latest fiscal year filed by the licensee with the Securities and Exchange Commission pursuant to the requirements of section 13 of the Securities and Exchange Act of 1934.
5. If, at any time, the licensee's most recent bond issuance ceases to be rated in any category of "A" or above by either Standard and Poors or Moodys, the licensee will provide notice in writing of such fact to the Agency within 20 days after publication of the change by the rating service. If the licensee's most recent bond issuance ceases to be rated in any category of A or above by both Standard and Poors and Moodys, the licensee no longer meets the requirements of Section B.1. of this appendix.
6. The applicant or licensee must provide to the Agency a written guarantee (a written commitment by a corporate officer) which states that the licensee will fund and carry out the required decommissioning activities or, upon issuance of an order by the Agency, the licensee will set up and fund a trust in the amount of the current cost estimates for decommissioning.

## APPENDIX E

### QUANTITIES FOR USE WITH DECOMMISSIONING

| Material             | Microcurie<br>* | Material      | Microcurie* |
|----------------------|-----------------|---------------|-------------|
| Americium-241        | 0.01            | Germanium-71  | 100         |
| Antimony-122         | 100             | Gold-198      | 100         |
| Antimony-124         | 10              | Gold-199      | 100         |
| Antimony-125         | 10              | Hafnium-181   | 10          |
| Arsenic-73           | 100             | Holmium-166   | 100         |
| Arsenic-74           | 10              | Hydrogen-3    | 1,000       |
| Arsenic-76           | 10              | Indium-113m   | 100         |
| Arsenic-77           | 100             | Indium-114m   | 10          |
| Barium-131           | 10              | Indium-115m   | 100         |
| Barium-133           | 10              | Indium-115    | 10          |
| Barium-140           | 10              | Iodine-125    | 1           |
| Bismuth-210          | 1               | Iodine-126    | 1           |
| Bromine-82           | 10              | Iodine-129    | 0.1         |
| Cadmium-109          | 10              | Iodine-131    | 1           |
| Cadmium-115m         | 10              | Iodine-132    | 10          |
| Cadmium-115          | 100             | Iodine-133    | 1           |
| Calcium-45           | 10              | Iodine-134    | 10          |
| Calcium-47           | 10              | Iodine-135    | 10          |
| Carbon-14            | 100             | Iridium-192   | 10          |
| Cerium-141           | 100             | Iridium-194   | 100         |
| Cerium-143           | 100             | Iron-55       | 100         |
| Cerium-144           | 1               | Iron-59       | 10          |
| Cesium-131           | 1,000           | Krypton-85    | 100         |
| Cesium-134m          | 100             | Krypton-87    | 10          |
| Cesium-134           | 1               | Lanthanum-140 | 10          |
| Cesium-135           | 10              | Lutetium-177  | 100         |
| Cesium-136           | 10              | Manganese-52  | 10          |
| Cesium-137           | 10              | Manganese-54  | 10          |
| Chlorine-36          | 10              | Manganese-56  | 10          |
| Chlorine-38          | 10              | Mercury-197m  | 100         |
| Chromium-51          | 1,000           | Mercury-197   | 100         |
| Cobalt-58m           | 10              | Mercury-203   | 10          |
| Cobalt-58            | 10              | Molybdenum-99 | 100         |
| Cobalt-60            | 1               | Neodymium-147 | 100         |
| Copper-64            | 100             | Neodymium-149 | 100         |
| Dysprosium-165       | 10              | Nickel-59     | 100         |
| Dysprosium-166       | 100             | Nickel-63     | 10          |
| Erbium-169           | 100             | Nickel-65     | 100         |
| Erbium-171           | 100             | Niobium-93m   | 10          |
| Europium-152 (9.2 h) | 100             | Niobium-95    | 10          |
| Europium-152 (13 yr) | 1               | Niobium-97    | 10          |
| Europium-154         | 1               | Osmium-185    | 10          |
| Europium-155         | 10              | Osmium-191m   | 100         |
| Florine-18           | 1,000           | Osmium-191    | 100         |
| Gadolinium-153       | 10              | Osmium-193    | 100         |
| Gadolinium-159       | 100             | Palladium-103 | 100         |
| Gallium-72           | 10              | Palladium-109 | 100         |

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

**QUANTITIES FOR USE WITH DECOMMISSIONING**

| <u>Material</u>  | <u>Microcuri<br/>e*</u> | <u>Material</u>      | <u>Microcurie<br/>*</u> |
|------------------|-------------------------|----------------------|-------------------------|
| Phosphorus-32    | 10                      | Technetium-97m       | 100                     |
| Platinum-191     | 100                     | Technetium-97        | 100                     |
| Platinum-193m    | 100                     | Technetium-99m       | 100                     |
| Platinum-193     | 100                     | Technetium-99        | 10                      |
| Platinum-197m    | 100                     | Tellurium-125m       | 10                      |
| Platinum-197     | 100                     | Tellurium-127m       | 10                      |
| Plutonium-239    | 0.01                    | Tellurium-127        | 100                     |
| Polonium-210     | 0.1                     | Tellurium-129m       | 10                      |
| Potassium-42     | 10                      | Tellurium-129        | 100                     |
| Praseodymium-142 | 100                     | Tellurium-131m       | 10                      |
| Praseodymium-143 | 100                     | Tellurium-132        | 10                      |
| Promethium-147   | 10                      | Terbium-160          | 10                      |
| Promethium-149   | 10                      | Thallium-200         | 100                     |
| Radium-226       | 0.01                    | Thallium-201         | 100                     |
| Rhenium-186      | 100                     | Thallium-202         | 100                     |
| Rhenium-188      | 100                     | Thallium-204         | 10                      |
| Rhodium-103m     | 100                     | Thorium (natural)**  | 100                     |
| Rhodium-105      | 100                     | Thulium-170          | 10                      |
| Rubidium-86      | 10                      | Thulium-171          | 10                      |
| Rubidium-87      | 10                      | Tin-113              | 10                      |
| Ruthenium-97     | 100                     | Tin-125              | 10                      |
| Ruthenium-103    | 10                      | Tungsten-181         | 10                      |
| Ruthenium-105    | 10                      | Tungsten-185         | 10                      |
| Ruthenium-106    | 1                       | Tungsten-187         | 100                     |
| Samarium-153     | 100                     | Uranium (natural)*** | 100                     |
| Scandium-46      | 10                      | Uranium-233          | 0.01                    |
| Scandium-47      | 100                     | Uranium-234          | 0.01                    |
| Scandium-48      | 10                      | Uranium-235          | 0.01                    |
| Selenium-75      | 10                      | Vanadium-48          | 10                      |
| Silicon-31       | 100                     | Xenon-131m           | 1,000                   |
| Silver-105       | 10                      | Xenon-133            | 100                     |
| Silver-110m      | 1                       | Xenon-135            | 100                     |
| Silver-111       | 100                     | Ytterbium-175        | 100                     |
| Sodium-22        | 1                       | Yttrium-90           | 10                      |
| Sodium-24        | 10                      | Yttrium-91           | 10                      |
| Strontium-85     | 10                      | Yttrium-92           | 100                     |
| Strontium-89     | 1                       | Yttrium-93           | 100                     |
| Strontium-90     | 0.1                     | Zinc-65              | 10                      |
| Strontium-91     | 10                      | Zinc-69m             | 100                     |
| Strontium-92     | 10                      | Zinc-69              | 1,000                   |
| Sulfur -35       | 100                     | Zirconium-93         | 10                      |
| Tantalum-182     | 10                      | Zirconium-95         | 10                      |
| Technetium-96    | 10                      | Zirconium-97         | 10                      |

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

\*\* Based on alpha disintegration rate of Th-232, Th-230 and their daughter products.

\*\*\* Based on alpha disintegration rate of U-238, U-234, and U-235.

## QUANTITIES FOR USE WITH DECOMMISSIONING

| Material   | Microcurie* |
|--|-------------|
| Any alpha emitting radionuclide not listed above or mixtures of alpha emitters of unknown composition                          | 0.01        |
| Any radionuclide other than alpha emitting radionuclides, not listed above or mixtures of beta emitters of unknown composition | 0.1         |

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

**NOTE:** Where there is involved a combination of isotopes in known amounts, the limit for the combination should be derived as follows: Determine, for each isotope in the combination, the ratio between the quantity present in the combination and the limit otherwise established for the specific isotope when not in combination. The sum of such ratios for all the isotopes in the combination may not exceed "1" -- that is, unity.

# PART D

## STANDARDS FOR PROTECTION AGAINST RADIATION

### GENERAL PROVISIONS

#### 1. Purpose.

- A. Part D establishes standards for protection against ionizing radiation resulting from activities conducted pursuant to licenses or registrations issued by the Agency. These regulations are issued pursuant to the 22 MRSA, the Radiation Control 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.

- 2. **Scope.** Except as specifically provided in other Parts of these regulations, 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, or to voluntary participation in medical research programs.

#### 3. Definitions.

- A. As used in Part D:

- (1) "**Annual limit on intake**" (ALI) means the derived limit for the amount of radioactive material taken into the body of an adult worker by inhalation or ingestion in a year. ALI is the smaller value of intake of a given radionuclide in a year by the reference man that would result in a committed effective dose equivalent of 0.05 Sv (5 rem) or a committed dose equivalent of 0.5 Sv (50 rem) to any individual organ or tissue. ALI values for intake by ingestion and by inhalation of selected radionuclides are given in Table I, Columns 1 and 2, of Appendix B.
- (2) "**Class**" means a classification scheme for inhaled material according to its rate of clearance from the pulmonary region of the lung. Materials are classified as D, W, or Y, which applies to a range of clearance half-times: for Class D, Days, of less than 10 days, for Class W, Weeks, from 10 to 100 days, and for Class Y, Years, of greater than 100 days. For purposes of these regulations, "lung class" and "inhalation class" are equivalent terms.
- (3) "**Declared pregnant woman**" means a woman who has voluntarily informed the licensee, in writing, of her pregnancy and the estimated date of conception. The declaration remains in effect until the declared pregnant woman withdraws the declaration in writing or is no longer pregnant..
- (4) "**Derived air concentration**" (DAC) means the concentration of a given radionuclide in air which, if breathed by the reference man for a working year of 2,000 hours under conditions of light work, results in an intake of one ALI. For purposes of these regulations, the condition of light work is an inhalation rate of 1.2 cubic meters of air per hour for 2,000 hours in a year. DAC values are given in Table I, Column 3, of Appendix B.

- (5) **"Derived air concentration-hour"** (DAC-hour) means the product of the concentration of radioactive material in air, expressed as a fraction or multiple of the derived air concentration for each radionuclide, and the time of exposure to that radionuclide, in hours. A licensee or registrant may take 2,000 DAC-hours to represent one ALI, equivalent to a committed effective dose equivalent of 0.05 Sv (5 rem).
- (6) **"Dosimetry processor"** means an individual or an organization that processes and evaluates individual monitoring devices in order to determine the radiation dose delivered to the monitoring devices.
- (7) **"Inhalation class"** [see "Class"].
- (8) **"Lung class"** [see "Class"].
- (9) **"Nonstochastic effect"** means a health effect, the severity of which varies with the dose and for which a threshold is believed to exist. Radiation-induced cataract formation is an example of a nonstochastic effect. For purposes of these regulations, "deterministic effect" is an equivalent term.
- (10) **"Planned special exposure"** means an infrequent exposure to radiation, separate from and in addition to the annual occupational dose limits.
- (11) **"Quarter"** means a period of time equal to one-fourth of the year observed by the licensee, approximately 13 consecutive weeks, providing that the beginning of the first quarter in a year coincides with the starting date of the year and that no day is omitted or duplicated in consecutive quarters.
- (12) **"Reference Man"** means a hypothetical aggregation of human physical and physiological characteristics determined by international consensus. These characteristics may be used by researchers and public health workers to standardize results of experiments and to relate biological insult to a common base. A description of the Reference Man is contained in the International Commission on Radiological Protection report, ICRP Publication 23, "Report of the Task Group on Reference Man."
- (13) **"Respiratory protection device"** means an apparatus, such as a respirator, used to reduce the individual's intake of airborne radioactive materials.
- (14) **"Sanitary sewerage"** means a system of public sewers for carrying off waste water and refuse, but excluding sewage treatment facilities, septic tanks, and leach fields owned or operated by the licensee or registrant.
- (15) **"Stochastic effect"** means a health effect that occurs randomly and for which the probability of the effect occurring, rather than its severity, is assumed to be a linear function of dose without threshold. Hereditary effects and cancer incidence are examples of stochastic effects. For purposes of these regulations, "probabilistic effect" is an equivalent term.
- (16) **"Very high radiation area"** means an area, accessible to individuals, in which radiation levels from radiation sources external to the body could result in an individual receiving an absorbed dose in excess of 500 rads (5 Gy) in 1 hour at 1 meter from a source of radiation or 1 meter from any surface that the radiation penetrates.<sup>1/</sup>

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<sup>1/</sup> At very high doses received at high dose rates, units of absorbed dose, gray and rad, are appropriate, rather than units of dose equivalent, sievert and rem.

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

ORGAN DOSE WEIGHTING FACTORS

| <u>Organ/Tissue</u> | <u><math>w_T</math></u> |
|---------------------|-------------------------|
| Gonads              | 0.25                    |
| Breast              | 0.15                    |
| Red bone marrow     | 0.12                    |
| Lung                | 0.12                    |
| Thyroid             | 0.03                    |
| Bone surfaces       | 0.03                    |
| <u>Remainder</u>    | <u>0.30<sup>a</sup></u> |
| <b>Whole Body</b>   | <b>1.00<sup>b</sup></b> |

- a 0.30 results from 0.06 for each of 5 "remainder" organs, excluding the skin and the lens of the eye, that receive the highest doses.
- b For the purpose of weighting the external whole body dose, for adding it to the internal dose, a single weighting factor,  $w_T = 1.0$ , has been specified. The use of other weighting factors for external exposure will be approved on a case-by-case basis until such time as specific guidance is issued.

#### 4. Implementation.

- A. 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.
- B. 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.
- C. 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.

### RADIATION PROTECTION PROGRAMS

#### 5. 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.41 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.5. B and notwithstanding the requirements in D.14, 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 10 mrem (0.1 mSv) per year from these emissions. If a licensee subject to this requirement exceeds this dose constraint, the licensee shall report the exceedance as provided in D.53 and promptly take appropriate corrective action to ensure against recurrence.

## OCCUPATIONAL DOSE LIMITS

### 6. 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.11, to the following dose limits:
- (1) An annual limit, which is the more limiting of:
    - (a) The total effective dose equivalent 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, and to 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 or to 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.11.E(1) and (2).
- C. The assigned deep dose equivalent and shallow dose equivalent shall be for the portion of the body receiving the highest exposure determined as follows:
- (1) 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; or
  - (2) *(Reserved.)*
- 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.46.
- 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.10.E.

## 7. Compliance with Requirements for Summation of External and Internal Doses.

- A. If the licensee or registrant is required to monitor pursuant to both D.18.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.18.A or only pursuant to D.18.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 pursuant to D.7.B, C and D. 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 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,  $w_T$ , and the committed dose equivalent,  $H_{T,50}$ , per unit intake is greater than 10 percent of the maximum weighted value of  $H_{T,50}$ , that is,  $w_T H_{T,50}$ , per 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.

## 8. 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.

## 9. 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.18, 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.24, 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. See Appendix B.
- D. If the licensee or registrant chooses to assess intakes of Class Y material using the measurements given in D.9.A(2) or (3), the licensee or registrant may delay the recording and reporting of the assessments for periods up to 7 months, unless otherwise required by D.52 or D.53. 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.18.B, and
  - (2) The concentration of any radionuclide disregarded is less 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. When determining the committed effective dose equivalent, the following information may be considered:
- (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) For an ALI and the associated DAC determined by the nonstochastic organ dose limit of 50 rem (0.5 Sv), the intake of radionuclides that would result in a committed effective dose equivalent of 5 rem (0.05 Sv), that is, the stochastic ALI, is listed in parentheses in Table I of Appendix B. The licensee or registrant may, as a simplifying assumption, use the stochastic ALI to determine committed effective dose equivalent. However, if the licensee or registrant uses the stochastic ALI, the licensee or registrant shall also demonstrate that the limit in D.6.A(1)(b) is met.

## 10. Determination of Prior Occupational Dose.

- A. For each individual who is likely to receive, in a year, an occupational dose requiring monitoring pursuant to D.18, 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; and
  - (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.10.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 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; and
  - (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.10.A, on 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.6.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 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 3 years after the record is made.

**11. 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.6 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.10.B during the lifetime of the individual for each individual involved.

E. Subject to D.6.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.6.A in any year; and
- 2) Five times the annual dose limits in D.6.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.45 and submits a written report in accordance with D.54.

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.6.A but shall be included in evaluations required by D.11.D and E.

**12. 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.6.

**13. Dose 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.46 for record keeping requirements.

B. The licensee or registrant shall make efforts to avoid substantial variation<sup>2/</sup> above a uniform monthly exposure rate to a declared pregnant woman so as to satisfy the limit in D.13.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 0.05 rem (0.5 mSv) 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 0.05 rem (0.5 mSv) during the remainder of the pregnancy.

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

**14. 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 0.1 rem (1 mSv) 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 G.27, 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.35,<sup>3/</sup> and

<sup>2/</sup> The National Council on Radiation Protection and Measurements recommended in NCRP Report No. 91 "Recommendations on Limits for Exposure to Ionizing Radiation" (June 1, 1987) that no more than 0.5 mSv (0.05 rem) to the embryo/fetus be received in any one month.

<sup>3/</sup> 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.

- (2) The dose in any unrestricted area from external sources 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. A licensee, registrant, or an applicant for a license or registration may apply for prior Agency authorization to operate up to an annual dose limit for an individual member of the public of 0.5 rem (5 mSv). This application shall include the following information:
    - (1) Demonstration of the need for and the expected duration of operations in excess of the limit in D.14.A.; and
    - (2) The licensee's or registrant's program to assess and control dose within the 0.5 rem (5 mSv) annual limit; and
    - (3) The procedures to be followed to maintain the dose ALARA.
  - D. 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.
  - E. 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.

#### **15. 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.14.
- B. A licensee or registrant shall show compliance with the annual dose limit in D.14 by:
  - (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 0.05 rem (0.5 mSv) 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.

## TESTING FOR LEAKAGE OR CONTAMINATION OF SEALED SOURCES

### 16. 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.16.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 6 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 6 months or at alternative intervals approved by the Agency, after evaluation of information specified by C.11.K(4) and (5) of these regulations, an Agreement State, a Licensing State, or the U.S. 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 3 months or at alternative intervals approved by the Agency, after evaluation of information specified by C.11.K(4) and (5) of these regulations, an Agreement State, a Licensing 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  $\mu$ Ci) 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  $\mu$ Ci) 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  $\mu$ Ci) of a radium daughter which has a half-life greater than 4 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 less than 30 days;
- (2) Sealed sources containing only radioactive material as a gas;
- (3) Sealed sources containing 3.7 MBq (100  $\mu$ Ci) or less of beta or photon- emitting material or 370 kBq (10  $\mu$ Ci) or less 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 6 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, a Licensing 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  $\mu$ Ci) or more of removable contamination on any test sample.
  - (2) Leakage of 37 Bq (0.001  $\mu$ Ci) 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  $\mu$ Ci) 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.58.

## **SURVEYS AND MONITORING**

### **17. General.**

- A. Each licensee or registrant shall make, or cause to be made, surveys 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 radioactive material; and
    - (c) The potential radiological hazards.
- B. 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.
- C. 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.6, with other applicable provisions of these regulations, or with conditions specified in a license or registration shall be processed and evaluated by a dosimetry processor:
  - (1) Holding current personnel dosimetry accreditation from the National Voluntary Laboratory Accreditation Program (NVLAP) of the National Institute of Standards and Technology; and

- (2) Approved in this accreditation process for the type of radiation or radiations included in the NVLAP program that most closely approximates the type of radiation or radiations for which the individual wearing the dosimeter is monitored.

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

### **18. 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 1 year from sources external to the body, a dose in excess of 10 percent of the limits in D.6.A; and
- (2) Minors likely to receive, in 1 year from sources external to the body, a deep dose equivalent in excess of 0.1 rem (1 mSv), a lens dose equivalent in excess of 0.15 rem (1.5 mSv), or a shallow dose equivalent to the skin or to the extremities in excess of 0.5 rem (5 mSv); and
- (3) Declared pregnant women likely to receive during the entire pregnancy, in 1 year from sources external to the body, a deep dose equivalent in excess of 0.1 rem (1 mSv); and
- (4) Individuals entering a high or very high radiation area.
- (5) Reserved

B. Each licensee or registrant shall monitor, to determine compliance with D.9, 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, in 1 year from radiation sources external to the body, a committed effective dose equivalent in excess of 0.1 rem (1 mSv).

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

### **19. 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 0.1 rem (1 mSv) in 1 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.19.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.19.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 3 days; and
  - (2) The dose rate at 1 meter from the external surface of any package does not exceed 0.01 rem (0.1 mSv) 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.19 if the registrant has met all the specific requirements for access and control specified in other applicable Parts of these regulations, such as, Part E for industrial radiography, Part F for x rays in the healing arts, and Part I for particle accelerators.

## **20. Control of Access to Very High Radiation Areas.**

- A. In addition to the requirements in D.19, 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 1 hour at 1 meter from a source of radiation or any surface through which the radiation penetrates. This requirement does not apply to rooms or areas in which diagnostic x-ray systems are the only source of radiation, or to non-self-shielded irradiators.
- 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.20.A if the registrant has met all the specific requirements for access and control specified in other applicable Parts of these regulations, such as, Part E for industrial radiography, Part F for x rays in the healing arts, and Part I for particle accelerators.

## **21. Control of Access to Very High Radiation Areas -- Irradiators.**

- A. Section D.21 applies to licensees or registrants with sources of radiation in non-self-shielded irradiators. Section D.21 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 1 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 1 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 1 hour.
- (2) Additional control devices shall be provided so that, upon failure of the entry control devices to function as required by D.21.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 1 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 1 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.21.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 1 hour.
  - (9) The entry control devices required in D.21.B(1) shall be tested for proper functioning. See D.49 for recordkeeping 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.21.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.21.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.21.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.21.B and C shall be established in such a way that no individual will be prevented from leaving the area.

## **RESPIRATORY PROTECTION AND CONTROLS TO RESTRICT INTERNAL EXPOSURE IN RESTRICTED AREAS**

- 22. 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.

### 23. 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.

### 24. 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.23,

- (1) Except as provided in D.24.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; and
  - (b) Surveys and bioassays, as appropriate, to evaluate actual intakes; and
  - (c) Testing of respirators for operability (user seal check for face sealing devices and functional check for others) immediately prior to each use; and
  - (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  $\geq 10$  times the APF for negative pressure devices, and a fit factor  $\geq 500$  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 1 year. Fit testing must be performed with the facepiece operating in the negative pressure mode.
- (5) 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.
- (6) 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.
- (7) 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.
- (8) 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 less;
  - (c) Carbon Monoxide (CO) content of 10 ppm or less;
  - (d) Carbon Dioxide content of 1,000 ppm or less; 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.

B. The Agency may impose restrictions in addition to the provisions of D.23 and D.24, and Appendix A of this Part, in order to:

- 1: 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
- 2: Limit the extent to which a licensee may use respiratory protection equipment instead of process or other engineering controls.

C. 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.

## **STORAGE AND CONTROL OF LICENSED OR REGISTERED SOURCES OF RADIATION**

**25. 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.

### **26. 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.

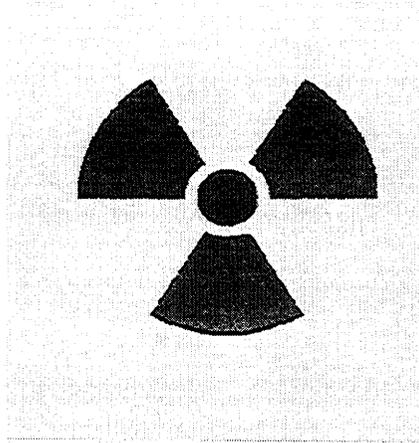
## **PRECAUTIONARY PROCEDURES**

### **27. Caution Signs.**

- A. Standard Radiation Symbol. Unless otherwise authorized by the Agency, the symbol prescribed by D.27 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.27.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.

## 28. 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)."

## 29. 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 less than 8 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.28 provided that the patient could be released from confinement pursuant to G.27 of these regulations.
- 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 0.005 rem (0.05 mSv) per hour.
- D. Rooms in hospitals or clinics that are used for teletherapy are exempt from the requirement to post caution signs under D.28 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.

## 30. 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.

## 31. 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;<sup>4/</sup> 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.

### **32. 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 these regulations, 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 labeled<sup>5/</sup> 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 these regulations; and
  - (2) Monitor the external surfaces of a labeled<sup>5/</sup> 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 L.2 and Appendix A to Part L of these regulations; 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.32.B as soon as practicable after receipt of the package, but not later than 3 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 3 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 L.15.H. of these regulations; or
  - (2) External radiation levels exceed the limits of L.15.I and J of these regulations.

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<sup>4/</sup> Labeling of packages containing radioactive materials is required by the U.S. Department of Transportation if the amount and type of radioactive material exceeds the limits for an excepted quantity or article as defined and limited by U.S. Department of Transportation regulations 49 CFR 173.403(m) and (w) and 173.421-424.

<sup>5/</sup> 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.

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.32.B, but are not exempt from the monitoring requirement in D.32.B for measuring radiation levels that ensures that the source is still properly lodged in its shield.

## WASTE DISPOSAL

### 33. 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.38, or in Parts C, M, or U<sup>6/</sup> of these regulations, 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.14; or
- (4) As authorized pursuant to D.34, D.35, D.36, or D.37.

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

**34. 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 these regulations, 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

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<sup>6/</sup> Part M and U are reserved.

- 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.

### 35. 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 1 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.35.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.35.A.

**36. 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.37 or as specifically approved by the Agency pursuant to D.34.

### 37. 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  $\mu$ Ci), or less, of hydrogen-3 or carbon-14 per gram of medium used for liquid scintillation counting; and
  - (2) 1.85 kBq (0.05  $\mu$ Ci), or less, 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.37.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.48.

### **38. Transfer for Disposal and Manifests.**

- A. The requirements of D.38, Appendices D and G of this Part are designed to control transfers of low-level radioactive waste intended for disposal at a licensed low-level radioactive waste disposal facility, establish a manifest tracking system, and supplement existing requirements concerning transfers and record keeping for those wastes.
- 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 II 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 III of Appendix D.

### **39. Compliance with Environmental and Health Protection Regulations.**

Nothing in D.33, D.34, D.35, D.36, D.37, or D.38 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 D.33, D.34, D.35, D.36, D.37, or D.38.

## **RECORDS**

### **40. 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.38, 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.

### **41. 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.41.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.41.A(2) for 3 years after the record is made.

**42. Records of Surveys.**

- A. Each licensee or registrant shall maintain records showing the results of surveys and calibrations required by D.17 and D.32.B The licensee or registrant shall retain these records for 3 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.24.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.

**43. Records of Tests for Leakage or Contamination of Sealed Sources.** Records of tests for leakage or contamination of sealed sources required by D.16 shall be kept in units of becquerel or microcurie and maintained for inspection by the Agency for 5 years after the records are made.

**44. Records of Prior Occupational Dose.**

- A. The licensee or registrant shall retain the records of prior occupational dose and exposure history as specified in D.10 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 3 years after the record is made.
- B. 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.

**45. Records of Planned Special Exposures.**

- A. For each use of the provisions of D.11 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; and
  - (2) The name of the management official who authorized the planned special exposure and a copy of the signed authorization; and
  - (3) What actions were necessary; and
  - (4) Why the actions were necessary; and
  - (5) What precautions were taken to assure that doses were maintained ALARA; and
  - (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.

#### **46. 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.18, 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; and
  - (2) The estimated intake of radionuclides, see D.7; and
  - (3) The committed effective dose equivalent assigned to the intake of radionuclides; and
  - (4) The specific information used to calculate the committed effective dose equivalent pursuant to D.9.C.; and
  - (5) The total effective dose equivalent when required by D.7; 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.46.A at intervals not to exceed 1 year.
- C. Record keeping Format. The licensee or registrant shall maintain the records specified in D.46.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.

#### **47. 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.14.
- B. The licensee or registrant shall retain the records required by D.47.A until the Agency terminates each pertinent license or registration requiring the record.

#### **48. Records of Waste Disposal.**

- A. Each licensee or registrant shall maintain records of the disposal of licensed or registered materials made pursuant to D.34, D.35, D.36, D.37, of these regulations, and disposal by burial in soil, including burials authorized before January 28, 1981.<sup>7</sup>
- B. The licensee or registrant shall retain the records required by D.48.A until the Agency terminates each pertinent license or registration requiring the record.

#### **49. 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.21.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.49.A for 3 years after the record is made.

- 50. 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.

### **REPORTS**

#### **51. 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 or registrant required to make a report pursuant to D.51.A shall, within 30 days after making the telephone report, make a written report to the Agency 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

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<sup>7/</sup> 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.

- (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.51 so that names of individuals who may have received exposure to radiation are stated in a separate and detachable portion of the report.

## 52. 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 rems) or more; or
    - (b) A lens dose equivalent of 0.75 Sv (75 rems) 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 rems); or
    - (b) A lens dose equivalent exceeding 0.15 Sv (15 rems); or
    - (c) A shallow-dose equivalent to the skin or extremities or a total organ dose equivalent exceeding 0.5 Sv (50 rems); 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.52 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.52.A and B to the Agency by telephone, telegram, mailgram, or facsimile to the Agency.
- E. The provisions of D.52 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.54.

**53. Reports of Exposures, Radiation Levels, and Concentrations of Radioactive Material Exceeding the Limits.**

- A. Reportable Events. In addition to the notification required by D.52, 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.52; or
- (2) Doses in excess of any of the following:
  - (a) The occupational dose limits for adults in D.6; or
  - (b) The occupational dose limits for a minor in D.12; or
  - (c) The limits for an embryo/fetus of a declared pregnant woman in D.13; or
  - (d) The limits for an individual member of the public in D.14; or
  - (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.14; 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.53.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, generally applicable environmental standards, and associated license or registration conditions.

- (2) Each report filed pursuant to D.53.A. shall include for each individual exposed: the name, Social Security account number, and date of birth. With respect to the limit for the embryo/fetus in D.13, the identifiers should be those of the declared pregnant woman. The report shall be prepared so that this information is stated in a separate and detachable portion of the report.

C. All licensees or registrants who make reports pursuant to D.53.A shall submit the report in writing to the Agency.

**54. 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.11, 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.45.

**55. Reports to Individuals of exceeding dose limits.** When a licensee is required, pursuant to D.53, D.54, or D.56 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 copy of 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.

**56. 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 these regulations; or
- (2) Possess or use at any time, for processing or manufacturing for distribution pursuant to Part C or G of these regulations, radioactive material in quantities exceeding any one of the following quantities:

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

<sup>a</sup> The Agency may require as a license condition, or by rule, regulation, or order, 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.56.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.18 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.56.B, covering the preceding year, on or before April 30 of each year. The licensee or registrant shall submit the report to the Agency.

**57. 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 these regulations.
- B. When a licensee or registrant is required pursuant to D.53 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 these regulations.

**58. Reports of Leaking or Contaminated Sealed Sources.** The licensee or registrant shall file a report within 5 days with the Agency if the test for leakage or contamination required pursuant to D.16. 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**

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

**RADIOLOGICAL CRITERIA FOR LICENSE TERMINATION**

**60. General Provisions and Scope.** The criteria in this subpart apply to the decommissioning of facilities licensed under Parts C, E, G and K of these regulations.

- 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 TEDE to the average member of the critical group the licensee shall determine the peak annual TEDE dose expected within the first 1000 years after decommissioning.
- 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.

- 61. 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.
- 62. 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.61. 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 TEDE 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 an account segregated from the licensee's assets and outside the licensee's administrative control as described in Part C.8.F.
    - (2) Surety method, insurance, or other guarantee method as described in Part C.8.F.;
    - (3) A statement of intent in the case of State, or local Government licensees, as described in Part C.8.F.; or
    - (4) 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 62.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;
- (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 3 years to assure that the institutional controls remain in place as necessary to meet the criteria of D.62.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.

### **63. Alternate Criteria for License Termination**

A. The Agency may terminate a license using alternate criteria greater than the dose criterion of parts D.61., D.62.B., and D.62.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.62. 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 (LTP) 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

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. 64.

**64. 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.62. and D.63., 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.63.

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.

**65. Minimization of Contamination.** 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..

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## APPENDIX A

### ASSIGNED PROTECTION FACTORS FOR RESPIRATOR <sup>A</sup>

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

See the following pages for footnotes.

- 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 are at least 99 percent efficient. Air purifying respirators with APF >100 must be equipped with particulate filters that are at least 99.97 percent efficient.
- 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.24 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 one-third of the intake occurs by absorption through the skin so that an overall protection factor of 3 is appropriate when atmosphere-supplying respirators are used to protect against tritium oxide. Exposure to radioactive noble gases is not considered a significant respiratory hazard, and protective actions for these contaminants should be based on external (submersion) dose considerations.
- 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 less than 10 days, for W from 10 to 100 days, and for Y greater than 100 days. Table II provides concentration limits for airborne and liquid effluents released to the general environment. Table III provides concentration limits for discharges to sanitary sewerage.

**Note:** The values in Tables I, II, and III are presented in the computer "E" notation. In this notation a value of 6E-02 represents a value of  $6 \times 10^{-2}$  or 0.06, 6E+2 represents  $6 \times 10^2$  or 600, and 6E+0 represents 6 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,  $w_T$ . This weighting factor is the proportion of the risk of stochastic effects resulting from irradiation of the organ or tissue, T, to the total risk of stochastic effects when the whole body is irradiated uniformly. The values of  $w_T$  are listed under the definition of weighting factor in 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  $w_T = 0.06$  is applicable to each of the five organs or tissues in the "remainder" category receiving the highest dose equivalents, and the dose equivalents of all other remaining tissues may be disregarded. The following portions of the GI tract, stomach, small intestine, upper large intestine, and lower large intestine, are to be treated as four separate organs.

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 nonstochastic ALIs ( $ALI_{ns}$ ) that contribute to the committed dose equivalent to the organ receiving the highest dose does not exceed unity, that is,  $(\text{intake (in } \mu\text{Ci)}) / ALI_{ns} \leq 1.0$ . If there is an external deep dose equivalent contribution of  $H_d$ , then this sum must be less than  $1 - (H_d/50)$ , instead of  $\leq 1.0$ .

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

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

$$DAC = ALI(\text{in mCi}) / (2000 \text{ hours per working year} \times 60 \text{ minutes/hour} \times 2 \times 10^4 \text{ ml per minute}) = [ALI / 2.4 \times 10^9] \text{ mCi/ml}$$

where  $2 \times 10^4$  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  $2.4 \times 10^9$ , 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 0.1 rem limit for members of the public, a factor of 3 to adjust for the difference in exposure time and the inhalation rate for a worker and that for members of the public; and a factor of 2 to adjust the occupational values, derived for adults, so that they are applicable to other age groups.

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

The water concentrations were derived by taking the most restrictive occupational stochastic oral ingestion ALI and dividing by  $7.3 \times 10^7$ . The factor of  $7.3 \times 10^7$  (ml) includes the following components: the factors of 50 and 2 described above and a factor of  $7.3 \times 10^5$  (ml), which is the annual water intake of Reference 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  $7.3 \times 10^6$  (ml). The factor of  $7.3 \times 10^6$  (ml) is composed of a factor of  $7.3 \times 10^5$  (ml), the annual water intake by Reference 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 0.5 rem.

## LIST OF ELEMENTS

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

Appendix B

| Atomic No. | Radionuclide             | Class  | Table I             |          |            | Table II Effluent Concentrations |          | Table III Releases to Sewers           |
|------------|--------------------------|--|---------------------|----------|------------|----------------------------------|----------|--|
|            |                          |  | Occupational Values |          |            | Col. 1                           | Col. 2   | Monthly Average Concentration (μCi/ml) |
|            |                          |  | Col. 1              | Col. 2   | Col. 3     | Air                              | Water    |  |
|            |                          |  | Oral Ingestion      |          | Inhalation | (μCi/ml)                         | (μCi/ml) |  |
| ALI (μCi)  | ALI (μCi)                | DAC (μCi/ml)   | (μCi/ml)            | (μCi/ml) |            |                                  |          |  |
| 1          | Hydrogen-3               | Water, DAC includes skin absorption  | 8E+4                | 8E+4     | 2E-5       | 1E-7                             | 1E-3     | 1E-2                                   |
| 4          | Beryllium-7              | Gas (HT or T2) Submersion1: Use above values as HT and T2 oxidize in air and in the body to HTO.<br>W, all compounds except those given for Y                    | 4E+4                | 2E+4     | 9E-6       | 3E-8                             | 6E-4     | 6E-3                                   |
| 4          | Beryllium-10             | Y, oxides, halides, and nitrates<br>W, see 7Be   | -                   | 2E+4     | 8E-6       | 3E-8                             | -        | -                                      |
|            |                          |  | 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-11 <sup>2</sup>   | Monoxide   | -                   | 1E+6     | 5E-4       | 2E-6                             | -        | -                                      |
|            |                          | Dioxide  | -                   | 6E+5     | 3E-4       | 9E-7                             | -        | -                                      |
|            |                          | Compounds  | 4E+5                | 4E+5     | 2E-4       | 6E-7                             | 6E-3     | 6E-2                                   |
| 6          | Carbon-14                | Monoxide   | -                   | 2E+6     | 7E-4       | 2E-6                             | -        | -                                      |
|            |                          | Dioxide  | -                   | 2E+5     | 9E-5       | 3E-7                             | -        | -                                      |
|            |                          | Compounds  | 2E+3                | 2E+3     | 1E-6       | 3E-9                             | 3E-5     | 3E-4                                   |
| 9          | Fluorine-18 <sup>2</sup> | D, fluorides of H, Li, Na, K, Rb, Cs, and Fr   | 5E+4                | 7E+4     | 3E-5       | 1E-7                             | -        | -                                      |
|            |                          |  | St wall (5E+4)      | -        | -          | -                                | 7E-4     | 7E-3                                   |
|            |                          | W, fluorides of Be, Mg, Ca, Sr, Ba, Ra, Al, Ga, In, Tl, As, Sb, Bi, Fe, Ru, Os, Co, Ni, Pd, Pt, Cu, Ag, Au, Zn, Cd, Hg, Sc, Y, Ti, Zr, V, Nb, Ta, Mn, Tc, and Re | -                   | 9E+4     | 4E-5       | 1E-7                             | -        | -                                      |
|            |                          | Y, lanthanum fluoride  | -                   | 8E+4     | 3E-5       | 1E-7                             | -        | -                                      |
| 11         | Sodium-22                | D, all compounds   | 4E+2                | 6E+2     | 3E-7       | 9E-10                            | 6E-6     | 6E-5                                   |
| 11         | Sodium-24                | D, all compounds   | 4E+3                | 5E+3     | 2E-6       | 7E-9                             | 5E-5     | 5E-4                                   |
| 12         | Magnesium-28             | D, all compounds except those given for W  | 7E+2                | 2E+3     | 7E-7       | 2E-9                             | 9E-6     | 9E-5                                   |
|            |                          | W, oxides, hydroxides, carbides, halides, and nitrates   | -                   | 1E+3     | 5E-7       | 2E-9                             | -        | -                                      |
| 13         | Aluminum-26              | D, all compounds except those given for W  | 4E+2                | 6E+1     | 3E-8       | 9E-11                            | 6E-6     | 6E-5                                   |
|            |                          | W, oxides, hydroxides, carbides, halides, and nitrates   | -                   | 9E+1     | 4E-8       | 1E-10                            | -        | -                                      |
| 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 Zn <sup>2+</sup> , S <sup>3+</sup> , Mg <sup>2+</sup> , Fe <sup>3+</sup> , Bi <sup>3+</sup> , and lanthanides                                   | -                   | 4E+2     | 2E-7       | 5E-10                            | -        | -                                      |
| 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, sulfides of Sr, Ba, Ge, Sn, Pb, As, Sb, Bi, Cu, Ag, Au, Zn, Cd, Hg, W, and Mo. Sulfates of Ca, Sr, Ba, Ra, As, Sb, and Bi                   | 6E+3                | -        | -          | -                                | -        | -                                      |
|            |                          |  | -                   | 2E+3     | 9E-7       | 3E-9                             | -        | -                                      |

Appendix B

| Atomic No. | Radionuclide              | Class  | Table I<br>Occupational Values |                  |              | Table II<br>Effluent Concentrations |                | Table III<br>Releases to Sewers        |
|------------|---------------------------|--|--------------------------------|------------------|--------------|-------------------------------------|----------------|--|
|            |                           |  | Col. 1                         | Col. 2           | Col. 3       | Col. 1                              | Col. 2         | Monthly Average Concentration (μCi/ml) |
|            |                           |  | Oral                           |                  |              | Air (μCi/ml)                        | Water (μCi/ml) |  |
|            |                           |  | Ingestion                      |                  |              |                                     |                |  |
|            |                           |  | ALI (μCi)                      | ALI (μCi)        | DAC (μCi/ml) |                                     |                |  |
| 17         | Chlorine-36               | D, chlorides of H, Li, Na, K, Rb, Cs, and Fr<br>W, chlorides of lanthanides, Be, Mg, Ca, Sr, Ba, Ra, Al, Ga, In, Tl, Ge, Sn, Pb, As, Sb, Bi, Fe, Ru, Os, Co, Rh, Ir, Ni, Pd, Pt, Cu, Ag, Au, Zn, Cd, Hg, Sc, Y, Ti, Zr, Hf, V, Nb, Ta, Cr, Mo, W, Mn, Tc, and Re | 2E+3                           | 2E+3             | 1E-6         | 3E-9                                | 2E-5           | 2E-4                                   |
| 17         | Chlorine-38 <sup>2</sup>  | D, see 36Cl  | -<br>2E+4<br>St wall (3E+4)    | 2E+2<br>4E+4     | 1E-7<br>2E-5 | 3E-10<br>6E-8                       | -<br>-         | -<br>-                                 |
| 17         | Chlorine-39 <sup>2</sup>  | W, see 36Cl<br>D, see 36Cl   | -<br>2E+4<br>St wall (4E+4)    | 5E+4<br>5E+4     | 2E-5<br>2E-5 | 6E-8<br>7E-8                        | -<br>3E-4<br>- | -<br>3E-3<br>-                         |
| 18         | Argon-37                  | Submersion1  | -                              | 6E+4             | 2E-5         | 8E-8                                | -              | -                                      |
| 18         | Argon-39                  | Submersion1  | -                              | -                | 1E+0         | 6E-3                                | -              | -                                      |
| 18         | Argon-41                  | Submersion1  | -                              | -                | 2E-4         | 8E-7                                | -              | -                                      |
| 19         | Potassium-40              | D, all compounds   | 3E+2                           | 4E+2             | 2E-7         | 6E-10                               | 4E-6           | 4E-5                                   |
| 19         | Potassium-42              | D, all compounds   | 5E+3                           | 5E+3             | 2E-6         | 7E-9                                | 6E-5           | 6E-4                                   |
| 19         | Potassium-43              | D, all compounds   | 6E+3                           | 9E+3             | 4E-6         | 1E-8                                | 9E-5           | 9E-4                                   |
| 19         | Potassium-44 <sup>2</sup> | D, all compounds   | 2E+4<br>St wall (4E+4)         | 7E+4             | 3E-5         | 9E-8                                | -              | -                                      |
| 19         | Potassium-45 <sup>2</sup> | D, all compounds   | 3E+4<br>St wall (5E+4)         | 1E+5             | 5E-5         | 2E-7                                | 5E-4<br>-      | 5E-3<br>-                              |
| 20         | Calcium-41                | W, all compounds   | 3E+3                           | 4E+3             | 2E-6         | -                                   | 7E-4           | 7E-3                                   |
| 20         | Calcium-45                | W, all compounds   | Bone surf (4E+3)               | Bone surf (4E+3) | -            | 5E-9                                | 6E-5           | 6E-4                                   |
| 20         | Calcium-47                | W, all compounds   | 2E+3                           | 8E+2             | 4E-7         | 1E-9                                | 2E-5           | 2E-4                                   |
| 21         | Scandium-43               | Y, all compounds   | 8E+2                           | 9E+2             | 4E-7         | 1E-9                                | 1E-5           | 1E-4                                   |
| 21         | Scandium-44m              | Y, all compounds   | 7E+3                           | 2E+4             | 9E-6         | 3E-8                                | 1E-4           | 1E-3                                   |
| 21         | Scandium-44               | Y, all compounds   | 5E+2                           | 7E+2             | 3E-7         | 1E-9                                | 7E-6           | 7E-5                                   |
| 21         | Scandium-46               | Y, all compounds   | 4E+3                           | 1E+4             | 5E-6         | 2E-8                                | 5E-5           | 5E-4                                   |
| 21         | Scandium-47               | Y, all compounds   | 9E+2                           | 2E+2             | 1E-7         | 3E-10                               | 1E-5           | 1E-4                                   |
| 21         | Scandium-47               | Y, all compounds   | 2E+3<br>LLI wall (3E+3)        | 3E+3             | 1E-6         | 4E-9                                | -              | -                                      |
| 21         | Scandium-48               | Y, all compounds   | 8E+2                           | 1E+3             | 6E-7         | 2E-9                                | 4E-5           | 4E-4                                   |
| 21         | Scandium-49 <sup>2</sup>  | Y, all compounds   | 2E+4                           | 5E+4             | 2E-5         | 8E-8                                | 1E-5           | 1E-4                                   |
| 22         | Titanium-44               | D, all compounds except those given for W and Y<br>W, oxides, hydroxides, carbides, halides, and nitrates  | 3E+2                           | 1E+1             | 5E-9         | 2E-11                               | 4E-6           | 4E-5                                   |
| 22         | Titanium-45               | Y, SrTiO<br>D, see 44Ti<br>W, see 44Ti<br>Y, see 44Ti  | -<br>9E+3                      | 3E+1<br>3E+4     | 1E-8<br>1E-5 | 4E-11<br>3E-8                       | -<br>1E-4      | -<br>1E-3                              |
| 23         | Vanadium-47 <sup>2</sup>  | D, all compounds except those given for W<br>W, oxides, hydroxides, carbides, and halides  | 3E+4<br>St wall (3E+4)         | 8E+4             | 3E-5         | 1E-7                                | 4E-4           | 4E-3                                   |
| 23         | Vanadium-48               | D, see 47V<br>W, see 47V   | -<br>6E+2                      | 3E+0<br>6E+2     | 1E-8<br>3E-7 | 4E-11<br>9E-10                      | -<br>9E-6      | -<br>9E-5                              |
| 23         | Vanadium-49               | D, see 47V   | 7E+4<br>LLI wall (9E+4)        | 3E+4             | 1E-5         | -                                   | -              | -                                      |
| 24         | Chromium-48               | W, see 47V<br>D, all compounds except those given for W and Y<br>W, halides and nitrates<br>Y, oxides and hydroxides   | -<br>6E+3                      | 3E+1<br>7E+3     | 1E-8<br>3E-6 | 4E-11<br>1E-8                       | -<br>-         | -<br>8E-4                              |
| 24         | Chromium-49 <sup>2</sup>  | D, see 48Cr<br>W, see 48Cr<br>Y, see 48Cr  | 3E+4                           | 8E+4             | 4E-5         | 1E-7                                | 4E-4           | 4E-3                                   |
| 24         | Chromium-51               | D, see 48Cr<br>W, see 48Cr<br>Y, see 48Cr  | 4E+4                           | 5E+4             | 2E-5         | 6E-8                                | 5E-4           | 5E-3                                   |
| 25         | Manganese-51 <sup>2</sup> | D, all compounds except those given for W<br>W, oxides, hydroxides, halides, and nitrates  | 2E+4                           | 5E+4             | 2E-5         | 7E-8                                | 3E-4           | 3E-3                                   |

Appendix B

| Atomic No. | Radionuclide               | Class   | Table I             |                  |              | Table II Effluent Concentrations |                | Table III Releases to Sewers           |
|------------|----------------------------|---|---------------------|------------------|--------------|----------------------------------|----------------|--|
|            |                            |   | Occupational Values |                  |              | Col. 1                           | Col. 2         | Monthly Average Concentration (μCi/ml) |
|            |                            |   | Col. 1              | Col. 2           | Col. 3       | Air                              | Water          |  |
|            |                            |   | Oral                |                  |              |                                  |                |  |
| Ingestion  |                            |   |                     |                  |              |                                  |                |  |
|            |                            |   | ALI (μCi)           | ALI (μCi)        | DAC (μCi/ml) | Air (μCi/ml)                     | Water (μCi/ml) |  |
| 25         | Manganese-52m <sup>2</sup> | 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-60m <sup>2</sup>    | 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-62m <sup>2</sup>    | 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-60 <sup>2</sup>     | D, all compounds except those given for W and Y | 3E+4                | 9E+4             | 4E-5         | 1E-7                             | -              | -                                      |
|            |                            |   | St wall (3E+4)      | -                | -            | -                                | 4E-4           | 4E-3                                   |
|            |                            | W, sulfides, halides, and nitrates              | -                   | 1E+5             | 5E-5         | 2E-7                             | -              | -                                      |
|            |                            | Y, oxides and hydroxides                        | -                   | 1E+5             | 4E-5         | 1E-7                             | -              | -                                      |
| 29         | Copper-61                  | D, see 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                             | -              | -                                      |

Appendix B

| Atomic<br>No. | Radionuclide              | Class  | Table I<br>Occupational Values         |   |                              | Table II<br>Effluent<br>Concentrations |                                | Table III<br>Releases to<br>Sewers                           |
|---------------|---------------------------|--|--|---|------------------------------|--|--------------------------------|--|
|               |                           |  | Col. 1                                 | Col. 2                                  | Col. 3                       | Col. 1                                 | Col. 2                         | Monthly<br>Average<br>Concentration<br>( $\mu\text{Ci/ml}$ ) |
|               |                           |  | Oral                                   |   |                              | Air<br>( $\mu\text{Ci/ml}$ )           | Water<br>( $\mu\text{Ci/ml}$ ) |  |
|               |                           |  | Ingestion<br>ALI<br>( $\mu\text{Ci}$ ) | Inhalation<br>ALI<br>( $\mu\text{Ci}$ ) | DAC<br>( $\mu\text{Ci/ml}$ ) |  |                                |  |
| 29            | Copper-64                 | D, see 60Cu<br>W, see 60Cu<br>Y, see 60Cu                    | 1E+4<br>-<br>-                         | 3E+4<br>2E+4<br>2E+4                    | 1E-5<br>1E-5<br>9E-6         | 4E-8<br>3E-8<br>3E-8                   | 2E-4<br>-<br>-                 | 2E-3<br>-<br>-   |
| 29            | Copper-67                 | D, see 60Cu<br>W, see 60Cu<br>Y, see 60Cu                    | 5E+3<br>-<br>-                         | 8E+3<br>5E+3<br>5E+3                    | 3E-6<br>2E-6<br>2E-6         | 1E-8<br>7E-9<br>6E-9                   | 6E-5<br>-<br>-                 | 6E-4<br>-<br>-   |
| 30            | Zinc-62                   | Y, all compounds   | 1E+3                                   | 3E+3                                    | 1E-6                         | 4E-9                                   | 2E-5                           | 2E-4   |
| 30            | Zinc-63 <sup>2</sup>      | Y, all compounds   | 2E+4                                   | 7E+4                                    | 3E-5                         | 9E-8                                   | -                              | -  |
|               |                           |  | St wall<br>(3E+4)                      | -                                       | -                            | -                                      | 3E-4                           | 3E-3   |
| 30            | Zinc-65                   | Y, all compounds   | 4E+2                                   | 3E+2                                    | 1E-7                         | 4E-10                                  | 5E-6                           | 5E-5   |
| 30            | Zinc-69m                  | Y, all compounds   | 4E+3                                   | 7E+3                                    | 3E-6                         | 1E-8                                   | 6E-5                           | 6E-4   |
| 30            | Zinc-69 <sup>2</sup>      | Y, all compounds   | 6E+4                                   | 1E+5                                    | 6E-5                         | 2E-7                                   | 8E-4                           | 8E-3   |
| 30            | Zinc-71m                  | Y, all compounds   | 6E+3                                   | 2E+4                                    | 7E-6                         | 2E-8                                   | 8E-5                           | 8E-4   |
| 30            | Zinc-72                   | Y, all compounds   | 1E+3                                   | 1E+3                                    | 5E-7                         | 2E-9                                   | 1E-5                           | 1E-4   |
| 31            | Gallium-65 <sup>2</sup>   | D, all compounds except<br>those given for W                 | 5E+4<br>St wall<br>(6E+4)              | 2E+5<br>-                               | 7E-5<br>-                    | 2E-7<br>-                              | -<br>9E-4                      | -<br>9E-3  |
|               |                           | W, oxides, hydroxides,<br>carbides, halides, and<br>nitrates | -                                      | 2E+5                                    | 8E-5                         | 3E-7                                   | -                              | -  |
| 31            | Gallium-66                | D, see 65Ga<br>W, see 65Ga                                   | 1E+3<br>-                              | 4E+3<br>3E+3                            | 1E-6<br>1E-6                 | 5E-9<br>4E-9                           | 1E-5<br>-                      | 1E-4<br>-  |
| 31            | Gallium-67                | D, see 65Ga<br>W, see 65Ga                                   | 7E+3<br>-                              | 1E+4<br>1E+4                            | 6E-6<br>4E-6                 | 2E-8<br>1E-8                           | 1E-4<br>-                      | 1E-3<br>-  |
| 31            | Gallium-68 <sup>2</sup>   | D, see 65Ga<br>W, see 65Ga                                   | 2E+4<br>-                              | 4E+4<br>5E+4                            | 2E-5<br>2E-5                 | 6E-8<br>7E-8                           | 2E-4<br>-                      | 2E-3<br>-  |
| 31            | Gallium-70 <sup>2</sup>   | D, see 65Ga  | 5E+4<br>St wall<br>(7E+4)              | 2E+5<br>-                               | 7E-5<br>-                    | 2E-7<br>-                              | -<br>1E-3                      | -<br>1E-2  |
|               |                           | W, see 65Ga  | -                                      | 2E+5                                    | 8E-5                         | 3E-7                                   | -                              | -  |
| 31            | Gallium-72                | D, see 65Ga<br>W, see 65Ga                                   | 1E+3<br>-                              | 4E+3<br>3E+3                            | 1E-6<br>1E-6                 | 5E-9<br>4E-9                           | 2E-5<br>-                      | 2E-4<br>-  |
| 31            | Gallium-73                | D, see 65Ga<br>W, see 65Ga                                   | 5E+3<br>-                              | 2E+4<br>2E+4                            | 6E-6<br>6E-6                 | 2E-8<br>2E-8                           | 7E-5<br>-                      | 7E-4<br>-  |
| 32            | Germanium-66              | D, all compounds except<br>those given for W                 | 2E+4                                   | 3E+4                                    | 1E-5                         | 4E-8                                   | 3E-4                           | 3E-3   |
|               |                           | W, oxides, sulfides,<br>and halides                          | -                                      | 2E+4                                    | 8E-6                         | 3E-8                                   | -                              | -  |
| 32            | Germanium-67 <sup>2</sup> | D, see 66Ge  | 3E+4<br>St wall<br>(4E+4)              | 9E+4<br>-                               | 4E-5<br>-                    | 1E-7<br>-                              | -<br>6E-4                      | -<br>6E-3  |
|               |                           | W, see 66Ge  | -                                      | 1E+5                                    | 4E-5                         | 1E-7                                   | -                              | -  |
| 32            | Germanium-68              | D, see 66Ge<br>W, see 66Ge                                   | 5E+3<br>-                              | 4E+3<br>1E+2                            | 2E-6<br>4E-8                 | 5E-9<br>1E-10                          | 6E-5<br>-                      | 6E-4<br>-  |
| 32            | Germanium-69              | D, see 66Ge<br>W, see 66Ge                                   | 1E+4<br>-                              | 2E+4<br>8E+3                            | 6E-6<br>3E-6                 | 2E-8<br>1E-8                           | 2E-4<br>-                      | 2E-3<br>-  |
| 32            | Germanium-71              | D, see 66Ge<br>W, see 66Ge                                   | 5E+5<br>-                              | 4E+5<br>4E+4                            | 2E-4<br>2E-5                 | 6E-7<br>6E-8                           | 7E-3<br>-                      | 7E-2<br>-  |
| 32            | Germanium-75 <sup>2</sup> | D, see 66Ge  | 4E+4<br>St wall<br>(7E+4)              | 8E+4<br>-                               | 3E-5<br>-                    | 1E-7<br>-                              | -<br>9E-4                      | -<br>9E-3  |
|               |                           | W, see 66Ge  | -                                      | 8E+4                                    | 4E-5                         | 1E-7                                   | -                              | -  |
| 32            | Germanium-77              | D, see 66Ge<br>W, see 66Ge                                   | 9E+3<br>-                              | 1E+4<br>6E+3                            | 4E-6<br>2E-6                 | 1E-8<br>8E-9                           | 1E-4<br>-                      | 1E-3<br>-  |
| 32            | Germanium-78 <sup>2</sup> | D, see 66Ge  | 2E+4<br>St wall<br>(2E+4)              | 2E+4<br>-                               | 9E-6<br>-                    | 3E-8<br>-                              | -<br>3E-4                      | -<br>3E-3  |
|               |                           | W, see 66Ge  | -                                      | 2E+4                                    | 9E-6                         | 3E-8                                   | -                              | -  |
| 33            | Arsenic-69 <sup>2</sup>   | W, all compounds   | 3E+4<br>St wall<br>(4E+4)              | 1E+5<br>-                               | 5E-5<br>-                    | 2E-7<br>-                              | -<br>6E-4                      | -<br>6E-3  |
|               |                           | 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<br>LLI wall<br>(5E+3)             | 5E+3<br>-                               | 2E-6<br>-                    | 7E-9<br>-                              | -<br>6E-5                      | -<br>6E-4  |
| 33            | Arsenic-78 <sup>2</sup>   | W, all compounds   | 8E+3                                   | 2E+4                                    | 9E-6                         | 3E-8                                   | 1E-4                           | 1E-3   |
| 34            | Selenium-70 <sup>2</sup>  | D, all compounds except<br>those given for W                 | 2E+4                                   | 4E+4                                    | 2E-5                         | 5E-8                                   | 1E-4                           | 1E-3   |
|               |                           | W, oxides, hydroxides,<br>carbides, and<br>elemental Se      | 1E+4                                   | 4E+4                                    | 2E-5                         | 6E-8                                   | -                              | -  |

Appendix B

| Atomic No. | Radionuclide              | Class  | Table I             |           |              | Table II                |                | Table III                              |
|------------|---------------------------|--|---------------------|-----------|--------------|-------------------------|----------------|--|
|            |                           |  | Occupational Values |           |              | Effluent Concentrations |                | Releases to Sewers                     |
|            |                           |  | Col. 1              | Col. 2    | Col. 3       | Col. 1                  | Col. 2         | Monthly Average Concentration (μCi/ml) |
|            |                           |  | Oral                |           |              |                         |                |  |
| Ingestion  |                           |  | Inhalation          |           |              |                         |                |  |
|            |                           |  | ALI (μCi)           | ALI (μCi) | DAC (μCi/ml) | Air (μCi/ml)            | Water (μCi/ml) |  |
| 34         | Selenium-73m <sup>2</sup> | 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-81m <sup>2</sup> | 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-81 <sup>2</sup>  | 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-83 <sup>2</sup>  | 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-74m <sup>2</sup>  | D, bromides of H, Li, Na, K, Rb, Cs, and Fr  | 1E+4                | 4E+4      | 2E-5         | 5E-8                    | -              | -                                      |
|            |                           | St wall (2E+4)   | -                   | -         | -            | -                       | 3E-4           | 3E-3                                   |
|            |                           | W, bromides of lanthanides, Be, Mg, Ca, Sr, Ba, Ra, Al, Ga, In, Tl, Ge, Sn, Pb, As, Sb, Bi, Fe, Ru, Os, Co, Rh, Ir, Ni, Pd, Pt, Cu, Ag, Au, Zn, Cd, Hg, Sc, Y, Ti, Zr, Hf, V, Nb, Ta, Mn, Tc, and Re | -                   | 4E+4      | 2E-5         | 6E-8                    | -              | -                                      |
| 35         | Bromine-74 <sup>2</sup>   | D, see 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-75 <sup>2</sup>   | 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-80 <sup>2</sup>   | 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-84 <sup>2</sup>   | 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-74 <sup>2</sup>   | Submersion I   | -                   | -         | 3E-6         | 1E-8                    | -              | -                                      |
| 36         | Krypton-76                | Submersion I   | -                   | -         | 9E-6         | 4E-8                    | -              | -                                      |
| 36         | Krypton-77 <sup>2</sup>   | Submersion I   | -                   | -         | 4E-6         | 2E-8                    | -              | -                                      |
| 36         | Krypton-79                | Submersion I   | -                   | -         | 2E-5         | 7E-8                    | -              | -                                      |
| 36         | Krypton-81                | Submersion I   | -                   | -         | 7E-4         | 3E-6                    | -              | -                                      |
| 36         | Krypton-83m <sup>2</sup>  | Submersion I   | -                   | -         | 1E-2         | 5E-5                    | -              | -                                      |
| 36         | Krypton-85m               | Submersion I   | -                   | -         | 2E-5         | 1E-7                    | -              | -                                      |
| 36         | Krypton-85                | Submersion I   | -                   | -         | 1E-4         | 7E-7                    | -              | -                                      |
| 36         | Krypton-87 <sup>2</sup>   | Submersion I   | -                   | -         | 5E-6         | 2E-8                    | -              | -                                      |
| 36         | Krypton-88                | Submersion I   | -                   | -         | 2E-6         | 9E-9                    | -              | -                                      |
| 37         | Rubidium-79 <sup>2</sup>  | D, all compounds   | 4E+4                | 1E+5      | 5E-5         | 2E-7                    | -              | -                                      |
|            |                           | St wall (6E+4)   | -                   | -         | -            | -                       | 8E-4           | 8E-3                                   |
|            |                           | W, see 74mBr   | -                   | 6E+4      | 3E-5         | 9E-8                    | -              | -                                      |
| 37         | Rubidium-81m <sup>2</sup> | D, all compounds   | 2E+5                | 3E+5      | 1E-4         | 5E-7                    | -              | -                                      |
|            |                           | St wall (3E+5)   | -                   | -         | -            | -                       | 4E-3           | 4E-2                                   |
|            |                           | W, see 74mBr   | -                   | 6E+4      | 3E-5         | 9E-8                    | -              | -                                      |
| 37         | Rubidium-81               | D, all compounds   | 4E+4                | 5E+4      | 2E-5         | 7E-8                    | 5E-4           | 5E-3                                   |
| 37         | Rubidium-82m              | D, all compounds   | 1E+4                | 2E+4      | 7E-6         | 2E-8                    | 2E-4           | 2E-3                                   |
| 37         | Rubidium-83               | D, all compounds   | 6E+2                | 1E+3      | 4E-7         | 1E-9                    | 9E-6           | 9E-5                                   |
| 37         | Rubidium-84               | D, all compounds   | 5E+2                | 8E+2      | 3E-7         | 1E-9                    | 7E-6           | 7E-5                                   |
| 37         | Rubidium-86               | D, all compounds   | 5E+2                | 8E+2      | 3E-7         | 1E-9                    | 7E-6           | 7E-5                                   |
| 37         | Rubidium-87               | D, all compounds   | 1E+3                | 2E+3      | 6E-7         | 2E-9                    | 1E-5           | 1E-4                                   |
| 37         | Rubidium-88 <sup>2</sup>  | D, all compounds   | 2E+4                | 6E+4      | 3E-5         | 9E-8                    | -              | -                                      |
|            |                           | St wall (3E+4)   | -                   | -         | -            | -                       | 4E-4           | 4E-3                                   |

## Appendix B

| Atomic No. | Radionuclide               | Class   | Table I<br>Occupational Values |                     |              | Table II<br>Effluent Concentrations |                | Table III<br>Releases to Sewers        |
|------------|----------------------------|---|--------------------------------|---------------------|--------------|-------------------------------------|----------------|--|
|            |                            |   | Col. 1                         | Col. 2              | Col. 3       | Col. 1                              | Col. 2         | Monthly Average Concentration (μCi/ml) |
|            |                            |   | Oral                           |                     |              | Air (μCi/ml)                        | Water (μCi/ml) |  |
|            |                            |   | Ingestion                      |                     |              |                                     |                |  |
|            |                            |   | ALI (μCi)                      | ALI (μCi)           | DAC (μCi/ml) |                                     |                |  |
| 37         | Rubidium-89 <sup>2</sup>   | D, all compounds  | 4E+4<br>St wall<br>(6E+4)      | 1E+5                | 6E-5         | 2E-7                                | -              | -                                      |
| 38         | Strontium-80 <sup>2</sup>  | D, all soluble compounds except SrTiO<br>Y, all insoluble compounds and SrTiO | 4E+3                           | 1E+4                | 5E-6         | 2E-8                                | 6E-5           | 9E-3                                   |
| 38         | Strontium-81 <sup>2</sup>  | D, see 80Sr   | 3E+4                           | 8E+4                | 3E-5         | 2E-8                                | -              | -                                      |
|            |                            | Y, see 80Sr   | 2E+4                           | 8E+4                | 3E-5         | 1E-7                                | 3E-4           | 3E-3                                   |
| 38         | Strontium-82               | D, see 80Sr   | 3E+2                           | 4E+2                | 2E-7         | 6E-10                               | -              | -                                      |
|            |                            |   | LLI wall<br>(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-85m <sup>2</sup> | 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<br>(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<br>(4E+1)            | Bone surf<br>(2E+1) | -            | -                                   | 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-86m <sup>2</sup>   | W, all compounds except those given for Y                                     | 2E+4                           | 6E+4                | 2E-5         | 8E-8                                | 3E-4           | 3E-3                                   |
|            |                            | Y, oxides and hydroxides  | -                              | 5E+4                | 2E-5         | 8E-8                                | -              | -                                      |
| 39         | Yttrium-86                 | W, see 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<br>(5E+2)             | -                   | -            | -                                   | 7E-6           | 7E-5                                   |
|            |                            | Y, see 86mY   | -                              | 6E+2                | 3E-7         | 9E-10                               | -              | -                                      |
| 39         | Yttrium-91m <sup>2</sup>   | 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<br>(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-94 <sup>2</sup>    | W, see 86mY   | 2E+4                           | 8E+4                | 3E-5         | 1E-7                                | -              | -                                      |
|            |                            |   | St wall<br>(3E+4)              | -                   | -            | -                                   | 4E-4           | 4E-3                                   |
|            |                            | Y, see 86mY   | -                              | 8E+4                | 3E-5         | 1E-7                                | -              | -                                      |
| 39         | Yttrium-95 <sup>2</sup>    | W, see 86mY   | 4E+4                           | 2E+5                | 6E-5         | 2E-7                                | -              | -                                      |
|            |                            |   | St wall<br>(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                                | -              | -                                      |

Appendix B

| Atomic No. | Radionuclide                | Class                                     | Table I<br>Occupational Values               |                  |              | Table II<br>Effluent Concentrations |                | Table III<br>Releases to Sewers        |      |
|------------|-----------------------------|---|--|------------------|--------------|-------------------------------------|----------------|--|------|
|            |                             |   | Col. 1                                       | Col. 2           | Col. 3       | Col. 1                              | Col. 2         | Monthly Average Concentration (μCi/ml) |      |
|            |                             |   | Oral   |                  |              | Air (μCi/ml)                        | Water (μCi/ml) |  |      |
|            |                             |   | Ingestion                                    |                  |              |                                     |                |  |      |
|            |                             |   | ALI (μCi)                                    | ALI (μCi)        | DAC (μCi/ml) |                                     |                |  |      |
| 40         | Zirconium-93                | D, see 86Zr                               | 1E+3   | 6E+0             | 3E-9         | -                                   | -              | -                                      |      |
|            |                             |   | Bone surf (3E+3)                             | Bone surf (2E+1) | -            | 2E-11                               | 4E-5           | 4E-4                                   |      |
|            |                             | W, see 86Zr                               | -  | 2E+1             | 1E-8         | -                                   | -              | -                                      |      |
|            |                             | Y, see 86Zr                               | -  | Bone surf (6E+1) | -            | 9E-11                               | -              | -                                      |      |
|            |                             |   | -  | 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         | -                                   | -              | -                                      |      |
|            |                             | 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                                   |      |
|            |                             |   | -  | 1E+3             | 6E-7         | 2E-9                                | -              | -                                      |      |
|            |                             | W, see 86Zr                               | -  | 1E+3             | 5E-7         | 2E-9                                | -              | -                                      |      |
|            |                             | Y, see 86Zr                               | -  | 1E+3             | 5E-7         | 2E-9                                | -              | -                                      |      |
| 41         | Niobium-88 <sup>2</sup>     | W, all compounds except those given for Y | 5E+4   | 2E+5             | 9E-5         | 3E-7                                | -              | -                                      |      |
|            |                             |   | St wall (7E+4)                               | -                | -            | -                                   | 1E-3           | 1E-2                                   |      |
|            |                             |   | -  | 2E+5             | 9E-5         | 3E-7                                | -              | -                                      |      |
| 41         | Niobium-89 <sup>2</sup>     | Y, oxides and hydroxides                  | 1E+4   | 4E+4             | 2E-5         | 6E-8                                | 1E-4           | 1E-3                                   |      |
|            |                             |   | W, see 88Nb (66 min)                         | -                | 4E+4         | 2E-5                                | 5E-8           | -                                      | -    |
|            |                             |   | Y, see 88Nb                                  | 5E+3             | 2E+4         | 8E-6                                | 3E-8           | 7E-5                                   | 7E-4 |
|            |                             | W, see 88Nb (122 min)                     | -  | 2E+4             | 6E-6         | 2E-8                                | -              | -                                      |      |
| 41         | Niobium-89                  | Y, see 88Nb                               | 1E+3   | 3E+3             | 1E-6         | 4E-9                                | 1E-5           | 1E-4                                   |      |
|            |                             |   | W, see 88Nb                                  | -                | 2E+3         | 1E-6                                | 3E-9           | -                                      | -    |
|            |                             |   | Y, see 88Nb                                  | 9E+3             | 2E+3         | 8E-7                                | 3E-9           | -                                      | -    |
| 41         | Niobium-90                  | W, see 88Nb                               | LLI wall (1E+4)                              | -                | -            | -                                   | 2E-4           | 2E-3                                   |      |
|            |                             |   | -  | 2E+2             | 7E-8         | 2E-10                               | -              | -                                      |      |
|            |                             |   | 9E+2   | 2E+2             | 8E-8         | 3E-10                               | 1E-5           | 1E-4                                   |      |
| 41         | Niobium-93m                 | Y, see 88Nb                               | -  | 2E+1             | 6E-9         | 2E-11                               | -              | -                                      |      |
|            |                             |   | W, see 88Nb                                  | 2E+3             | 3E+3         | 1E-6                                | 4E-9           | -                                      | -    |
|            |                             |   | Y, see 88Nb                                  | LLI wall (2E+3)  | -            | -                                   | -              | 3E-5                                   | 3E-4 |
|            |                             | W, see 88Nb                               | 2E+3   | 1E+3             | 5E-7         | 2E-9                                | 3E-5           | 3E-4                                   |      |
| 41         | Niobium-95                  | Y, see 88Nb                               | -  | 1E+3             | 5E-7         | 2E-9                                | -              | -                                      |      |
|            |                             |   | W, see 88Nb                                  | 1E+3             | 5E-7         | 2E-9                                | -              | -                                      |      |
|            |                             |   | Y, see 88Nb                                  | 1E+3             | 3E+3         | 1E-6                                | 4E-9           | 2E-5                                   | 2E-4 |
| 41         | Niobium-96                  | W, see 88Nb                               | -  | 2E+3             | 1E-6         | 3E-9                                | -              | -                                      |      |
|            |                             |   | Y, see 88Nb                                  | 2E+4             | 8E+4         | 3E-5                                | 1E-7           | 3E-4                                   | 3E-3 |
|            |                             |   | W, see 88Nb                                  | -                | 7E+4         | 3E-5                                | 1E-7           | -                                      | -    |
| 41         | Niobium-97 <sup>2</sup>     | Y, see 88Nb                               | 1E+4   | 5E+4             | 2E-5         | 8E-8                                | 2E-4           | 2E-3                                   |      |
|            |                             |   | W, see 88Nb                                  | -                | 5E+4         | 2E-5                                | 7E-8           | -                                      | -    |
|            |                             |   | Y, see 88Nb                                  | 4E+3             | 7E+3         | 3E-6                                | 1E-8           | 3E-5                                   | 3E-4 |
| 42         | Molybdenum-90               | D, all compounds except those given for Y | 2E+3   | 5E+3             | 2E-6         | 6E-9                                | -              | -                                      |      |
|            |                             |   | Y, oxides, hydroxides, and MoS               | 9E+3             | 2E+4         | 7E-6                                | 2E-8           | 6E-5                                   | 6E-4 |
|            |                             |   | D, see 90Mo                                  | 4E+3             | 1E+4         | 6E-6                                | 2E-8           | -                                      | -    |
| 42         | Molybdenum-93m              | Y, see 90Mo                               | 4E+3   | 5E+3             | 2E-6         | 8E-9                                | 5E-5           | 5E-4                                   |      |
|            |                             |   | D, see 90Mo                                  | 2E+4             | 2E+2         | 8E-8                                | 2E-10          | -                                      | -    |
|            |                             |   | Y, see 90Mo                                  | 2E+3             | 3E+3         | 1E-6                                | 4E-9           | -                                      | -    |
| 42         | Molybdenum-93               | D, see 90Mo                               | LLI wall (1E+3)                              | -                | -            | -                                   | 2E-5           | 2E-4                                   |      |
|            |                             |   | Y, see 90Mo                                  | 1E+3             | 1E+3         | 6E-7                                | 2E-9           | -                                      | -    |
|            |                             |   | D, see 90Mo                                  | 4E+4             | 1E+5         | 6E-5                                | 2E-7           | -                                      | -    |
| 42         | Molybdenum-99               | Y, see 90Mo                               | St wall (5E+4)                               | -                | -            | -                                   | 7E-4           | 7E-3                                   |      |
|            |                             |   | -  | 1E+5             | 6E-5         | 2E-7                                | -              | -                                      |      |
|            |                             |   | D, see 90Mo                                  | 7E+4             | 2E+5         | 6E-5                                | 2E-7           | 1E-3                                   | 1E-2 |
| 43         | Technetium-93m <sup>2</sup> | Y, see 90Mo                               | -  | 3E+5             | 1E-4         | 4E-7                                | -              | -                                      |      |
|            |                             |   | D, all compounds except those given for W    | 3E+4             | 7E+4         | 3E-5                                | 1E-7           | 4E-4                                   | 4E-3 |
|            |                             |   | W, oxides, hydroxides, halides, and nitrates | -                | 1E+5         | 4E-5                                | 1E-7           | -                                      | -    |
| 43         | Technetium-93               | D, see 93mTc                              | 2E+4   | 4E+4             | 2E-5         | 6E-8                                | 3E-4           | 3E-3                                   |      |
|            |                             |   | W, see 93mTc                                 | -                | 6E+4         | 2E-5                                | 8E-8           | -                                      | -    |
|            |                             |   | D, see 93mTc                                 | 9E+3             | 2E+4         | 8E-6                                | 3E-8           | 1E-4                                   | 1E-3 |
| 43         | Technetium-94               | W, see 93mTc                              | -  | 2E+4             | 1E-5         | 3E-8                                | -              | -                                      |      |
|            |                             |   | 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-95m              | D, see 93mTc                              | 1E+4   | 2E+4             | 9E-6         | 3E-8                                | 1E-4           | 1E-3                                   |      |
|            |                             |   | W, see 93mTc                                 | -                | 2E+4         | 8E-6                                | 3E-8           | -                                      | -    |
|            |                             |   | D, see 93mTc                                 | 2E+5             | 3E+5         | 1E-4                                | 4E-7           | 2E-3                                   | 2E-2 |
| 43         | Technetium-95               | W, see 93mTc                              | -  | 2E+5             | 1E-4         | 3E-7                                | -              | -                                      |      |
|            |                             |   | D, see 93mTc                                 | 2E+3             | 3E+3         | 1E-6                                | 5E-9           | 3E-5                                   | 3E-4 |
|            |                             |   | W, see 93mTc                                 | -                | 2E+3         | 9E-7                                | 3E-9           | -                                      | -    |

## Appendix B

| Atomic No. | Radionuclide                | Class   | Table I                |                        |                                  | Table II                         |                                    | Table III                     |
|------------|-----------------------------|---|------------------------|------------------------|----------------------------------|----------------------------------|------------------------------------|-------------------------------|
|            |                             |   | Occupational Values    |                        |                                  | Effluent Concentrations          |                                    | Releases to Sewers            |
|            |                             |   | Col. 1                 | Col. 2                 | Col. 3                           | Col. 1                           | Col. 2                             | Monthly Average Concentration |
|            |                             |   | Oral                   |                        |                                  |                                  |                                    | Concentration                 |
|            |                             |   | Ingestion              | Inhalation             |                                  | ( $\mu\text{Ci}/\text{ml}$ )     |                                    |                               |
|            |                             |   | ALI ( $\mu\text{Ci}$ ) | ALI ( $\mu\text{Ci}$ ) | DAC ( $\mu\text{Ci}/\text{ml}$ ) | Air ( $\mu\text{Ci}/\text{ml}$ ) | Water ( $\mu\text{Ci}/\text{ml}$ ) |                               |
| 43         | Technetium-97m              | D, see 93mTc                                    | 5E+3                   | 7E+3                   | 3E-6                             | -                                | 6E-5                               | 6E-4                          |
|            |                             |   | -                      | St wall (7E+3)         | -                                | 1E-8                             | -                                  | -                             |
| 43         | Technetium-97               | W, see 93mTc                                    | -                      | 1E+3                   | 5E-7                             | 2E-9                             | -                                  | -                             |
|            |                             | 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                             | -                                  | -                             |
| 43         | Technetium-101 <sup>2</sup> | W, see 93mTc                                    | -                      | 7E+2                   | 3E-7                             | 9E-10                            | -                                  | -                             |
|            |                             | D, see 93mTc                                    | 9E+4                   | 3E+5                   | 1E-4                             | 5E-7                             | -                                  | -                             |
|            |                             |   | St wall (1E+5)         | -                      | -                                | -                                | 2E-3                               | 2E-2                          |
| 43         | Technetium-104 <sup>2</sup> | W, see 93mTc                                    | -                      | 4E+5                   | 2E-4                             | 5E-7                             | -                                  | -                             |
|            |                             | D, see 93mTc                                    | 2E+4                   | 7E+4                   | 3E-5                             | 1E-7                             | -                                  | -                             |
|            |                             |   | St wall (3E+4)         | -                      | -                                | -                                | 4E-4                               | 4E-3                          |
| 44         | Ruthenium-94 <sup>2</sup>   | W, see 93mTc                                    | -                      | 9E+4                   | 4E-5                             | 1E-7                             | -                                  | -                             |
|            |                             | D, all compounds except those given for W and Y | 2E+4                   | 4E+4                   | 2E-5                             | 6E-8                             | 2E-4                               | 2E-3                          |
|            |                             | W, halides                                      | -                      | 6E+4                   | 3E-5                             | 9E-8                             | -                                  | -                             |
| 44         | Ruthenium-97                | Y, oxides and hydroxides                        | -                      | 6E+4                   | 2E-5                             | 8E-8                             | -                                  | -                             |
|            |                             | D, see 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-103m <sup>2</sup>   | 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-107 <sup>2</sup>    | 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                             | -                                  | -                             |

Appendix B

| Atomic No. | Radionuclide             | Class   | Table I             |                |        | Table II                |        | Table III                              |
|------------|--------------------------|---|---------------------|----------------|--------|-------------------------|--------|--|
|            |                          |   | Occupational Values |                |        | Effluent Concentrations |        | Releases to Sewers                     |
|            |                          |   | Col. 1              | Col. 2         | Col. 3 | Col. 1                  | Col. 2 | Monthly Average Concentration (μCi/ml) |
|            |                          |   | Oral Ingestion      |                |        | Air                     | Water  |  |
| ALI (μCi)  | ALI (μCi)                | DAC (μCi/ml)                                    | (μCi/ml)            | (μCi/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 (4E+4)                                 | -                   | Kidneys (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-102 <sup>2</sup>  | 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-103 <sup>2</sup>  | 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-104m <sup>2</sup> | 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-104 <sup>2</sup>  | 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-106 <sup>2</sup>  | 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 (1E+3)                                 | -                   | Liver (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-115 <sup>2</sup>  | 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-104 <sup>2</sup> | 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 (4E+2)                                  | -                   | Kidneys (5E+1) | -      | 7E-11                   | 6E-6   | 6E-5                                   |
|            |                          | W, see 104Cd                                    | -                   | 1E+2           | 5E-8   | -                       | -      | -                                      |
|            |                          | Y, see 104Cd                                    | -                   | Kidneys (1E+2) | -      | 2E-10                   | -      | -                                      |
|            |                          |   | -                   | 1E+2           | 5E-8   | 2E-10                   | -      | -                                      |

Appendix B

| Atomic No. | Radionuclide                       | Class   | Table I             |           |              | Table II                |                | Table III                     |
|------------|------------------------------------|---|---------------------|-----------|--------------|-------------------------|----------------|-------------------------------|
|            |                                    |   | Occupational Values |           |              | Effluent Concentrations |                | Releases to Sewers            |
|            |                                    |   | Col. 1              | Col. 2    | Col. 3       | Col. 1                  | Col. 2         | Monthly Average Concentration |
|            |                                    |   | Oral Ingestion      |           |              | Inhalation              |                | Concentration                 |
|            |                                    |   | ALI (μCi)           | ALI (μCi) | DAC (μCi/ml) | Air (μCi/ml)            | Water (μCi/ml) | (μCi/ml)                      |
| 48         | Cadmium-113m                       | D, see 104Cd  | 2E+1                | 2E+0      | 1E-9         | -                       | -              | -                             |
|            |                                    | Kidneys   | Kidneys             | Kidneys   | -            | -                       | -              | -                             |
|            |                                    | (4E+1)  | (4E+0)              | -         | 5E-12        | 5E-7                    | 5E-6           | -                             |
|            | W, see 104Cd                       | -   | 8E+0                | 4E-9      | -            | -                       | -              | -                             |
|            |                                    |   | -                   | Kidneys   | -            | -                       | -              | -                             |
|            |                                    |   | -                   | (1E+1)    | -            | 2E-11                   | -              | -                             |
|            |                                    |   | -                   | 1E+1      | 5E-9         | 2E-11                   | -              | -                             |
| 48         | Cadmium-113                        | Y, see 104Cd  | 2E+1                | 2E+0      | 9E-10        | -                       | -              | -                             |
|            |                                    | D, see 104Cd  | Kidneys             | Kidneys   | -            | -                       | -              | -                             |
|            |                                    |   | (3E+1)              | (3E+0)    | -            | 5E-12                   | 4E-7           | 4E-6                          |
|            | W, see 104Cd                       | -   | -                   | 8E+0      | 3E-9         | -                       | -              | -                             |
|            |                                    |   | -                   | Kidneys   | -            | -                       | -              | -                             |
|            |                                    |   | -                   | (1E+1)    | -            | 2E-11                   | -              | -                             |
|            |                                    |   | -                   | 1E+1      | 6E-9         | 2E-11                   | -              | -                             |
| 48         | Cadmium-115m                       | Y, see 104Cd  | 3E+2                | 5E+1      | 2E-8         | -                       | 4E-6           | 4E-5                          |
|            |                                    | D, see 104Cd  | -                   | 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-110 <sup>2</sup> (69.1 min) | D, see 109In  | 2E+4                | 4E+4      | 2E-5         | 6E-8                    | 2E-4           | 2E-3                          |
|            |                                    | W, see 109In  | -                   | 6E+4      | 2E-5         | 8E-8                    | -              | -                             |
| 49         | Indium-110 (4.9 h)                 | D, see 109In  | 5E+3                | 2E+4      | 7E-6         | 2E-8                    | 7E-5           | 7E-4                          |
|            |                                    | 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-112 <sup>2</sup>            | 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-113m <sup>2</sup>           | 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-116m <sup>2</sup>           | 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-117m <sup>2</sup>           | 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-119m <sup>2</sup>           | 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-111 <sup>2</sup>               | 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                    | -              | -                             |

Appendix B

| Atomic No. | Radionuclide                         | Class   | Table I                    |              |              | Table II                |              | Table III                              |
|------------|--------------------------------------|---|----------------------------|--------------|--------------|-------------------------|--------------|--|
|            |                                      |   | Occupational Values        |              |              | Effluent Concentrations |              | Releases to Sewers                     |
|            |                                      |   | Col. 1                     | Col. 2       | Col. 3       | Col. 1                  | Col. 2       | Monthly Average Concentration (μCi/ml) |
|            |                                      |   | Oral Ingestion             |              | Inhalation   | Air                     | Water        |  |
| ALI (μCi)  | ALI (μCi)                            | DAC (μCi/ml)  | (μCi/ml)                   | (μCi/ml)     |              |                         |              |  |
| 50         | Tin-121m                             | D, see 110Sn  | 3E+3<br>LLI wall<br>(4E+3) | 9E+2         | 4E-7         | 1E-9                    | -            | -                                      |
| 50         | Tin-121                              | W, see 110Sn<br>D, see 110Sn  | 6E+3<br>LLI wall<br>(6E+3) | 5E+2<br>2E+4 | 2E-7<br>6E-6 | 8E-10<br>2E-8           | 5E-5<br>-    | 5E-4<br>-                              |
| 50         | Tin-123m <sup>2</sup>                | W, see 110Sn<br>D, see 110Sn  | 5E+4                       | 1E+4<br>1E+5 | 5E-6<br>5E-5 | 2E-8<br>2E-7            | 8E-5<br>7E-4 | 8E-4<br>7E-3                           |
| 50         | Tin-123                              | W, see 110Sn<br>D, see 110Sn  | 5E+2                       | 1E+5<br>6E+2 | 6E-5<br>3E-7 | 2E-7<br>9E-10           | -            | -                                      |
| 50         | Tin-125                              | W, see 110Sn<br>D, see 110Sn  | LLI wall<br>(6E+2)         | 2E+2         | 7E-8         | 2E-10                   | 9E-6         | 9E-5                                   |
| 50         | Tin-126                              | W, see 110Sn<br>D, see 110Sn  | 4E+2<br>LLI wall<br>(5E+2) | 9E+2         | 4E-7         | 1E-9                    | -            | -                                      |
| 50         | Tin-127                              | W, see 110Sn<br>D, see 110Sn  | 3E+2                       | 4E+2<br>6E+1 | 1E-7<br>2E-8 | 5E-10<br>8E-11          | 6E-6<br>4E-6 | 6E-5<br>4E-5                           |
| 50         | Tin-128 <sup>2</sup>                 | W, see 110Sn<br>D, see 110Sn  | 7E+3                       | 7E+1<br>2E+4 | 3E-8<br>8E-6 | 9E-11<br>3E-8           | -            | -                                      |
| 51         | Antimony-115 <sup>2</sup>            | D, all compounds except those given for W<br>W, oxides, hydroxides, halides, sulfides, sulfates, and nitrates | 9E+3                       | 3E+4<br>4E+4 | 1E-5<br>1E-5 | 4E-8<br>5E-8            | 1E-4         | 1E-3                                   |
| 51         | Antimony-116m <sup>2</sup>           | D, see 115Sb  | 8E+4                       | 2E+5         | 1E-4         | 3E-7                    | 1E-3         | 1E-2                                   |
| 51         | Antimony-1162                        | W, see 115Sb<br>D, see 115Sb  | 2E+4                       | 3E+5<br>1E+5 | 1E-4<br>6E-5 | 4E-7<br>2E-7            | 3E-4         | 3E-3                                   |
| 51         | Antimony-117                         | W, see 115Sb<br>D, see 115Sb  | 7E+4<br>St wall<br>(9E+4)  | 3E+5         | 1E-4         | 5E-7                    | 1E-3         | 1E-2                                   |
| 51         | Antimony-118m                        | W, see 115Sb<br>D, see 115Sb  | 7E+4                       | 2E+5<br>3E+5 | 9E-5<br>1E-4 | 3E-7<br>4E-7            | 9E-4         | 9E-3                                   |
| 51         | Antimony-119                         | W, see 115Sb<br>D, see 115Sb  | 6E+3                       | 2E+4<br>2E+4 | 8E-6<br>9E-6 | 3E-8<br>3E-8            | 7E-5         | 7E-4                                   |
| 51         | Antimony-1202 (16 min)               | W, see 115Sb<br>D, see 115Sb  | 5E+3                       | 2E+4<br>4E+5 | 2E-5<br>2E-4 | 6E-8<br>6E-7            | 2E-4         | 2E-3                                   |
| 51         | Antimony-120 (5.76 d)                | W, see 115Sb<br>D, see 115Sb  | 2E+4                       | 3E+4<br>4E+5 | 1E-5<br>2E-4 | 4E-8                    | -            | -                                      |
| 51         | Antimony-122                         | W, see 115Sb<br>D, see 115Sb  | 1E+5<br>St wall<br>(2E+5)  | 5E+5         | 2E-4         | 7E-7                    | 2E-3         | 2E-2                                   |
| 51         | Antimony-124m <sup>2</sup>           | W, see 115Sb<br>D, see 115Sb  | 1E+3                       | 2E+3<br>1E+3 | 9E-7<br>5E-7 | 3E-9                    | 1E-5         | 1E-4                                   |
| 51         | Antimony-124                         | W, see 115Sb<br>D, see 115Sb  | 9E+2                       | 1E+3<br>2E+3 | 5E-7<br>1E-6 | 2E-9                    | -            | -                                      |
| 51         | Antimony-125                         | W, see 115Sb<br>D, see 115Sb  | 8E+2<br>LLI wall<br>(8E+2) | 2E+3         | 1E-6         | 3E-9                    | 1E-5         | 1E-4                                   |
| 51         | Antimony-126m <sup>2</sup>           | W, see 115Sb<br>D, see 115Sb  | 7E+2                       | 1E+3<br>8E+5 | 4E-7<br>4E-4 | 2E-9                    | 3E-3         | 3E-2                                   |
| 51         | Antimony-127                         | W, see 115Sb<br>D, see 115Sb  | 3E+5                       | 6E+5<br>9E+2 | 2E-4<br>4E-7 | 8E-7                    | 7E-6         | 7E-5                                   |
| 51         | Antimony-128 <sup>2</sup> (10.4 min) | W, see 115Sb<br>D, see 115Sb  | 6E+2                       | 2E+2<br>2E+3 | 1E-7<br>1E-6 | 3E-10                   | 3E-5         | 3E-4                                   |
| 51         | Antimony-128 (9.01 h)                | W, see 115Sb<br>D, see 115Sb  | 5E+2                       | 5E+2<br>2E+3 | 2E-7<br>2E-7 | 7E-10                   | -            | -                                      |
| 51         | Antimony-129                         | W, see 115Sb<br>D, see 115Sb  | 5E+4<br>St wall<br>(7E+4)  | 2E+5         | 8E-5         | 3E-7                    | 9E-4         | 9E-3                                   |
| 51         | Antimony-130 <sup>2</sup>            | W, see 115Sb<br>D, see 115Sb  | 6E+2                       | 1E+3<br>5E+2 | 5E-7<br>2E-7 | 2E-9                    | 7E-6         | 7E-5                                   |
| 51         | Antimony-130 <sup>2</sup>            | W, see 115Sb<br>D, see 115Sb  | 8E+2                       | 2E+3         | 9E-7         | 3E-9                    | -            | -                                      |
| 51         | Antimony-130 <sup>2</sup>            | W, see 115Sb<br>D, see 115Sb  | LLI wall<br>(8E+2)         | 2E+3         | 9E-7         | 3E-9                    | -            | -                                      |
| 51         | Antimony-130 <sup>2</sup>            | W, see 115Sb<br>D, see 115Sb  | 7E+2                       | 9E+2<br>4E+5 | 4E-7<br>2E-4 | 1E-9                    | 1E-5         | 1E-4                                   |
| 51         | Antimony-130 <sup>2</sup>            | W, see 115Sb<br>D, see 115Sb  | 8E+4<br>St wall<br>(1E+5)  | 4E+5         | 2E-4         | 5E-7                    | -            | -                                      |
| 51         | Antimony-130 <sup>2</sup>            | W, see 115Sb<br>D, see 115Sb  | 4E+5                       | 4E+3<br>3E+3 | 2E-4<br>2E-6 | 6E-7                    | 1E-3         | 1E-2                                   |
| 51         | Antimony-130 <sup>2</sup>            | W, see 115Sb<br>D, see 115Sb  | 1E+3                       | 3E+3<br>9E+3 | 2E-6<br>4E-6 | 6E-9                    | 2E-5         | 2E-4                                   |
| 51         | Antimony-130 <sup>2</sup>            | W, see 115Sb<br>D, see 115Sb  | 3E+3                       | 9E+3<br>6E+4 | 4E-6<br>3E-5 | 1E-8                    | 4E-5         | 4E-4                                   |
| 51         | Antimony-130 <sup>2</sup>            | W, see 115Sb<br>D, see 115Sb  | 2E+4                       | 6E+4<br>8E+4 | 3E-5<br>3E-5 | 9E-8                    | 3E-4         | 3E-3                                   |

Appendix B

| Atomic No. | Radionuclide                | Class                                     | Table I<br>Occupational Values |                           |            | Table II<br>Effluent Concentrations |                | Table III<br>Releases to Sewers        |
|------------|-----------------------------|---|--------------------------------|---------------------------|------------|-------------------------------------|----------------|--|
|            |                             |   | Col. 1                         | Col. 2                    | Col. 3     | Col. 1                              | Col. 2         | Monthly Average Concentration (μCi/ml) |
|            |                             |   | Oral                           |                           |            | Air (μCi/ml)                        | Water (μCi/ml) |  |
|            |                             |   | Ingestion                      |                           | Inhalation |                                     |                |  |
| ALI (μCi)  | ALI (μCi)                   | DAC (μCi/ml)                              |                                |                           |            |                                     |                |  |
| 51         | Antimony-131 <sup>2</sup>   | D, see 115Sb                              | 1E+4<br>Thyroid<br>(2E+4)      | 2E+4<br>Thyroid<br>(4E+4) | 1E-5       | -                                   | -              | -                                      |
|            |                             | W, see 115Sb                              | -                              | 2E+4<br>Thyroid<br>(4E+4) | 1E-5       | 6E-8                                | 2E-4           | 2E-3                                   |
| 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       | -                                   | -              | -                                      |
|            |                             | W, see 116Te                              | Bone surf<br>(7E+2)            | Bone surf<br>(4E+2)       | -          | 5E-10                               | 1E-5           | 1E-4                                   |
| 52         | Tellurium-121               | D, see 116Te                              | -                              | 4E+2                      | 2E-7       | 6E-10                               | -              | -                                      |
|            |                             | W, see 116Te                              | 3E+3                           | 4E+3                      | 2E-6       | 6E-9                                | 4E-5           | 4E-4                                   |
| 52         | Tellurium-123m              | D, see 116Te                              | -                              | 3E+3                      | 1E-6       | 4E-9                                | -              | -                                      |
|            |                             | W, see 116Te                              | 6E+2                           | 2E+2                      | 9E-8       | -                                   | -              | -                                      |
|            |                             | D, see 116Te                              | Bone surf<br>(1E+3)            | Bone surf<br>(5E+2)       | -          | 8E-10                               | 1E-5           | 1E-4                                   |
| 52         | Tellurium-123               | W, see 116Te                              | -                              | 5E+2                      | 2E-7       | 8E-10                               | -              | -                                      |
|            |                             | D, see 116Te                              | 5E+2                           | 2E+2                      | 8E-8       | -                                   | -              | -                                      |
|            |                             | W, see 116Te                              | Bone surf<br>(1E+3)            | Bone surf<br>(5E+2)       | -          | 7E-10                               | 2E-5           | 2E-4                                   |
|            |                             | D, see 116Te                              | -                              | 4E+2                      | 2E-7       | -                                   | -              | -                                      |
| 52         | Tellurium-125m              | D, see 116Te                              | 1E+3                           | 4E+2                      | 2E-7       | -                                   | -              | -                                      |
|            |                             | W, see 116Te                              | Bone surf<br>(1E+3)            | Bone surf<br>(1E+3)       | -          | 1E-9                                | 2E-5           | 2E-4                                   |
| 52         | Tellurium-127m              | D, see 116Te                              | -                              | 7E+2                      | 3E-7       | 1E-9                                | -              | -                                      |
|            |                             | W, see 116Te                              | 6E+2                           | 3E+2                      | 1E-7       | -                                   | 9E-6           | 9E-5                                   |
|            |                             | D, see 116Te                              | -                              | Bone surf<br>(4E+2)       | -          | 6E-10                               | -              | -                                      |
| 52         | Tellurium-127               | W, see 116Te                              | -                              | 3E+2                      | 1E-7       | 4E-10                               | -              | -                                      |
|            |                             | 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-129 <sup>2</sup>  | 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       | -                                   | -              | -                                      |
|            |                             | W, see 116Te                              | Thyroid<br>(6E+2)              | Thyroid<br>(1E+3)         | -          | 2E-9                                | 8E-6           | 8E-5                                   |
|            |                             | D, see 116Te                              | -                              | 4E+2                      | 2E-7       | -                                   | -              | -                                      |
|            |                             | W, see 116Te                              | -                              | Thyroid<br>(9E+2)         | -          | 1E-9                                | -              | -                                      |
| 52         | Tellurium-131 <sup>2</sup>  | D, see 116Te                              | 3E+3                           | 5E+3                      | 2E-6       | -                                   | -              | -                                      |
|            |                             | W, see 116Te                              | Thyroid<br>(6E+3)              | Thyroid<br>(1E+4)         | -          | 2E-8                                | 8E-5           | 8E-4                                   |
|            |                             | D, see 116Te                              | -                              | 5E+3                      | 2E-6       | -                                   | -              | -                                      |
| 52         | Tellurium-132               | D, see 116Te                              | 2E+2                           | 2E+2                      | 9E-8       | 2E-8                                | -              | -                                      |
|            |                             | W, see 116Te                              | Thyroid<br>(7E+2)              | Thyroid<br>(8E+2)         | -          | 1E-9                                | 9E-6           | 9E-5                                   |
|            |                             | D, see 116Te                              | -                              | 2E+2                      | 9E-8       | -                                   | -              | -                                      |
|            |                             | W, see 116Te                              | -                              | Thyroid<br>(6E+2)         | -          | 9E-10                               | -              | -                                      |
| 52         | Tellurium-133m <sup>2</sup> | D, see 116Te                              | 3E+3                           | 5E+3                      | 2E-6       | -                                   | -              | -                                      |
|            |                             | W, see 116Te                              | Thyroid<br>(6E+3)              | Thyroid<br>(1E+4)         | -          | 2E-8                                | 9E-5           | 9E-4                                   |
|            |                             | D, see 116Te                              | -                              | 5E+3                      | 2E-6       | -                                   | -              | -                                      |
| 52         | Tellurium-133 <sup>2</sup>  | D, see 116Te                              | 1E+4                           | 2E+4                      | 9E-6       | 2E-8                                | -              | -                                      |
|            |                             | W, see 116Te                              | Thyroid<br>(3E+4)              | Thyroid<br>(6E+4)         | -          | 8E-8                                | 4E-4           | 4E-3                                   |
|            |                             | D, see 116Te                              | -                              | 2E+4                      | 9E-6       | -                                   | -              | -                                      |
|            |                             | W, see 116Te                              | -                              | Thyroid<br>(6E+4)         | -          | 8E-8                                | -              | -                                      |
| 52         | Tellurium-134 <sup>2</sup>  | D, see 116Te                              | 2E+4                           | 2E+4                      | 1E-5       | -                                   | -              | -                                      |
|            |                             | W, see 116Te                              | Thyroid<br>(2E+4)              | Thyroid<br>(5E+4)         | -          | 7E-8                                | 3E-4           | 3E-3                                   |
|            |                             | D, all compounds                          | -                              | 2E+4                      | 1E-5       | -                                   | -              | -                                      |
| 53         | Iodine-120m <sup>2</sup>    | D, all compounds                          | 1E+4                           | 2E+4                      | 9E-6       | 7E-8                                | -              | -                                      |
|            |                             | D, all compounds                          | Thyroid<br>(1E+4)              | -                         | -          | 3E-8                                | -              | -                                      |
| 53         | Iodine-120 <sup>2</sup>     | D, all compounds                          | 4E+3                           | 9E+3                      | 4E-6       | -                                   | 2E-4           | 2E-3                                   |
|            |                             | D, all compounds                          | Thyroid<br>(8E+3)              | Thyroid<br>(1E+4)         | -          | 2E-8                                | 1E-4           | 1E-3                                   |

Appendix B

| Atomic No. | Radionuclide             | Class            | Table I<br>Occupational Values |                        |              | Table II<br>Effluent Concentrations |                | Table III<br>Releases to Sewers        |
|------------|--------------------------|------------------|--------------------------------|------------------------|--------------|-------------------------------------|----------------|--|
|            |                          |                  | Col. 1                         | Col. 2                 | Col. 3       | Col. 1                              | Col. 2         | Monthly Average Concentration (μCi/ml) |
|            |                          |                  | Oral                           |                        |              | Air (μCi/ml)                        | Water (μCi/ml) |  |
|            |                          |                  | Ingestion ALI (μCi)            | Inhalation ALI (μCi)   | DAC (μCi/ml) |                                     |                |  |
| 53         | Iodine-121               | D, all compounds | 1E+4<br>Thyroid (3E+4)         | 2E+4<br>Thyroid (5E+4) | 8E-6         | -                                   | -              | -                                      |
| 53         | Iodine-123               | D, all compounds | 3E+3<br>Thyroid (1E+4)         | 6E+3<br>Thyroid (2E+4) | 3E-6         | 7E-8                                | 4E-4           | 4E-3                                   |
| 53         | Iodine-124               | D, all compounds | 5E+1<br>Thyroid (2E+2)         | 8E+1<br>Thyroid (3E+2) | 3E-8         | 2E-8                                | 1E-4           | 1E-3                                   |
| 53         | Iodine-125               | D, all compounds | 4E+1<br>Thyroid (1E+2)         | 6E+1<br>Thyroid (2E+2) | 3E-8         | 4E-10                               | 2E-6           | 2E-5                                   |
| 53         | Iodine-126               | D, all compounds | 2E+1<br>Thyroid (7E+1)         | 4E+1<br>Thyroid (1E+2) | 1E-8         | 3E-10                               | 2E-6           | 2E-5                                   |
| 53         | Iodine-128 <sup>2</sup>  | D, all compounds | 4E+4<br>St wall (6E+4)         | 1E+5                   | 5E-5         | 2E-7                                | -              | 1E-5                                   |
| 53         | Iodine-129               | D, all compounds | 5E+0<br>Thyroid (2E+1)         | 9E+0<br>Thyroid (3E+1) | 4E-9         | -                                   | 8E-4           | 8E-3                                   |
| 53         | Iodine-130               | D, all compounds | 4E+2<br>Thyroid (1E+3)         | 7E+2<br>Thyroid (2E+3) | 3E-7         | 4E-11                               | 2E-7           | 2E-6                                   |
| 53         | Iodine-131               | D, all compounds | 3E+1<br>Thyroid (9E+1)         | 5E+1<br>Thyroid (2E+2) | 2E-8         | -                                   | -              | 2E-4                                   |
| 53         | Iodine-132m <sup>2</sup> | D, all compounds | 4E+3<br>Thyroid (1E+4)         | 8E+3<br>Thyroid (2E+4) | 4E-6         | 2E-10                               | 1E-6           | 1E-5                                   |
| 53         | Iodine-132               | D, all compounds | 4E+3<br>Thyroid (9E+3)         | 8E+3<br>Thyroid (1E+4) | 3E-6         | 3E-8                                | 1E-4           | 1E-3                                   |
| 53         | Iodine-133               | D, all compounds | 1E+2<br>Thyroid (5E+2)         | 3E+2<br>Thyroid (9E+2) | 1E-7         | 2E-8                                | 1E-4           | 1E-3                                   |
| 53         | Iodine-134 <sup>2</sup>  | D, all compounds | 2E+4<br>Thyroid (3E+4)         | 5E+4                   | 2E-5         | 1E-9                                | 7E-6           | 7E-5                                   |
| 53         | Iodine-135               | D, all compounds | 8E+2<br>Thyroid (3E+3)         | 2E+3<br>Thyroid (4E+3) | 7E-7         | 6E-9                                | 4E-4           | 4E-3                                   |
| 54         | Xenon-120 <sup>2</sup>   | Submersion I     | -                              | -                      | 1E-5         | 4E-8                                | -              | -                                      |
| 54         | Xenon-121 <sup>2</sup>   | Submersion I     | -                              | -                      | 2E-6         | 1E-8                                | -              | -                                      |
| 54         | Xenon-122                | Submersion I     | -                              | -                      | 7E-5         | 3E-7                                | -              | -                                      |
| 54         | Xenon-123                | Submersion I     | -                              | -                      | 6E-6         | 3E-8                                | -              | -                                      |
| 54         | Xenon-125                | Submersion I     | -                              | -                      | 2E-5         | 7E-8                                | -              | -                                      |
| 54         | Xenon-127                | Submersion I     | -                              | -                      | 1E-5         | 6E-8                                | -              | -                                      |
| 54         | Xenon-129m               | Submersion I     | -                              | -                      | 2E-4         | 9E-7                                | -              | -                                      |
| 54         | Xenon-131m               | Submersion I     | -                              | -                      | 4E-4         | 2E-6                                | -              | -                                      |
| 54         | Xenon-133m               | Submersion I     | -                              | -                      | 1E-4         | 6E-7                                | -              | -                                      |
| 54         | Xenon-133                | Submersion I     | -                              | -                      | 1E-4         | 5E-7                                | -              | -                                      |
| 54         | Xenon-135m <sup>2</sup>  | Submersion I     | -                              | -                      | 9E-6         | 4E-8                                | -              | -                                      |
| 54         | Xenon-135                | Submersion I     | -                              | -                      | 1E-5         | 7E-8                                | -              | -                                      |
| 54         | Xenon-138 <sup>2</sup>   | Submersion I     | -                              | -                      | 4E-6         | 2E-8                                | -              | -                                      |
| 55         | Cesium-125 <sup>2</sup>  | D, all compounds | 5E+4<br>St wall (9E+4)         | 1E+5                   | 6E-5         | 2E-7                                | -              | -                                      |
| 55         | Cesium-127               | D, all compounds | 6E+4                           | 9E+4                   | 4E-5         | 1E-7                                | 9E-4           | 1E-2                                   |
| 55         | Cesium-129               | D, all compounds | 2E+4                           | 3E+4                   | 1E-5         | 5E-8                                | 3E-4           | 9E-3                                   |
| 55         | Cesium-130 <sup>2</sup>  | D, all compounds | 6E+4<br>St wall (1E+5)         | 2E+5                   | 8E-5         | 3E-7                                | -              | 3E-3                                   |
| 55         | Cesium-131               | D, all compounds | 2E+4                           | 3E+4                   | 1E-5         | 4E-8                                | 1E-3           | 1E-2                                   |
| 55         | Cesium-132               | D, all compounds | 3E+3                           | 4E+3                   | 2E-6         | 6E-9                                | 4E-5           | 3E-3                                   |
| 55         | Cesium-134m              | D, all compounds | 1E+5<br>St wall (1E+5)         | 1E+5                   | 6E-5         | 2E-7                                | -              | 4E-4                                   |
| 55         | Cesium-134               | D, all compounds | 7E+1                           | 1E+2                   | 4E-8         | 2E-10                               | 2E-3           | 2E-2                                   |
| 55         | Cesium-135m <sup>2</sup> | D, all compounds | 1E+5                           | 2E+5                   | 8E-5         | 3E-7                                | 9E-7           | 9E-6                                   |
| 55         | Cesium-135               | D, all compounds | 7E+2                           | 1E+3                   | 5E-7         | 2E-9                                | 1E-3           | 1E-2                                   |
| 55         | Cesium-136               | D, all compounds | 4E+2                           | 7E+2                   | 3E-7         | 9E-10                               | 1E-5           | 1E-4                                   |
| 55         | Cesium-137               | D, all compounds | 1E+2                           | 2E+2                   | 6E-8         | 2E-10                               | 6E-6           | 6E-5                                   |
| 55         | Cesium-138 <sup>2</sup>  | D, all compounds | 2E+4<br>St wall (3E+4)         | 6E+4                   | 2E-5         | 8E-8                                | -              | 1E-5                                   |
| 56         | Barium-126 <sup>2</sup>  | D, all compounds | 6E+3                           | 2E+4                   | 6E-6         | -                                   | 4E-4           | 4E-3                                   |
| 56         | Barium-128               | D, all compounds | 5E+2                           | 2E+3                   | 7E-7         | 2E-9                                | 8E-5           | 8E-4                                   |
| 56         | Barium-131m <sup>2</sup> | D, all compounds | 4E+5<br>St wall (5E+5)         | 1E+6                   | 6E-4         | 2E-6                                | 7E-6           | 7E-5                                   |
|            |                          |                  |                                |                        |              |                                     | 7E-3           | 7E-2                                   |

Appendix B

| Atomic No. | Radionuclide                  | Class  | Table I<br>Occupational Values |                      |              | Table II<br>Effluent Concentrations |                | Table III<br>Releases to Sewers        |
|------------|-------------------------------|--|--------------------------------|----------------------|--------------|-------------------------------------|----------------|--|
|            |                               |  | Col. 1                         | Col. 2               | Col. 3       | Col. 1                              | Col. 2         | Monthly Average Concentration (μCi/ml) |
|            |                               |  | Oral                           |                      |              | Air (μCi/ml)                        | Water (μCi/ml) |  |
|            |                               |  | Ingestion ALI (μCi)            | Inhalation ALI (μCi) | DAC (μCi/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-139 <sup>2</sup>       | D, all compounds                               | 1E+4                           | 3E+4                 | 1E-5         | 4E-8                                | 2E-4           | 2E-3                                   |
| 56         | Barium-140                    | D, all compounds                               | 5E+2                           | 1E+3                 | 6E-7         | 2E-9                                | -              | -                                      |
|            |                               |  | LLI wall (6E+2)                | -                    | -            | -                                   | 8E-6           | 8E-5                                   |
| 56         | Barium-141 <sup>2</sup>       | D, all compounds                               | 2E+4                           | 7E+4                 | 3E-5         | 1E-7                                | 3E-4           | 3E-3                                   |
| 56         | Barium-142 <sup>2</sup>       | D, all compounds                               | 5E+4                           | 1E+5                 | 6E-5         | 2E-7                                | 7E-4           | 7E-3                                   |
| 57         | Lanthanum-131 <sup>2</sup>    | D, all compounds except those given for W      | 5E+4                           | 1E+5                 | 5E-5         | 2E-7                                | 6E-4           | 6E-3                                   |
|            |                               | W, oxides and hydroxides                       | -                              | 2E+5                 | 7E-5         | 2E-7                                | -              | -                                      |
| 57         | Lanthanum-132                 | D, see 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-142 <sup>2</sup>    | 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-143 <sup>2</sup>    | D, see 131La                                   | 4E+4                           | 1E+5                 | 4E-5         | 1E-7                                | -              | -                                      |
|            |                               |  | St wall (4E+4)                 | -                    | -            | -                                   | 5E-4           | 5E-3                                   |
| 58         | Cerium-134                    | W, see 131La                                   | -                              | 9E+4                 | 4E-5         | 1E-7                                | -              | -                                      |
|            |                               | W, all compounds except those given for Y      | 5E+2                           | 7E+2                 | 3E-7         | 1E-9                                | -              | -                                      |
|            |                               |  | LLI wall (6E+2)                | -                    | -            | -                                   | 8E-6           | 8E-5                                   |
| 58         | Cerium-135                    | Y, oxides, hydroxides, and fluorides           | -                              | 7E+2                 | 3E-7         | 9E-10                               | -              | -                                      |
|            |                               | 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                                   |
| 58         | Cerium-137                    | Y, see 134Ce                                   | -                              | 4E+3                 | 2E-6         | 5E-9                                | -              | -                                      |
|            |                               | 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                                   |
| 58         | Cerium-143                    | Y, see 134Ce                                   | -                              | 6E+2                 | 2E-7         | 8E-10                               | -              | -                                      |
|            |                               | W, see 134Ce                                   | 1E+3                           | 2E+3                 | 8E-7         | 3E-9                                | -              | -                                      |
|            |                               |  | LLI wall (1E+3)                | -                    | -            | -                                   | 2E-5           | 2E-4                                   |
| 58         | Cerium-144                    | Y, see 134Ce                                   | -                              | 2E+3                 | 7E-7         | 2E-9                                | -              | -                                      |
|            |                               | W, see 134Ce                                   | 2E+2                           | 3E+1                 | 1E-8         | 4E-11                               | -              | -                                      |
|            |                               |  | LLI wall (3E+2)                | -                    | -            | -                                   | 3E-6           | 3E-5                                   |
| 59         | Praseodymium-136 <sup>2</sup> | Y, see 134Ce                                   | -                              | 1E+1                 | 6E-9         | 2E-11                               | -              | -                                      |
|            |                               | those given for Y                              | W, all compounds except        | 5E+4                 | 2E+5         | 1E-4                                | 3E-7           | -                                      |
|            |                               |  | St wall (7E+4)                 | -                    | -            | -                                   | 1E-3           | 1E-2                                   |
|            |                               | Y, oxides, hydroxides, carbides, and fluorides | -                              | 2E+5                 | 9E-5         | 3E-7                                | -              | -                                      |
| 59         | Praseodymium-137 <sup>2</sup> | W, see 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                                | -              | -                                      |

| Atomic No. | Radionuclide                   | Class  | Table I<br>Occupational Values |            |        | Table II<br>Effluent Concentrations |                | Table III<br>Releases to Sewers        |
|------------|--------------------------------|--|--------------------------------|------------|--------|-------------------------------------|----------------|--|
|            |                                |  | Col. 1                         | Col. 2     | Col. 3 | Col. 1                              | Col. 2         | Monthly Average Concentration (μCi/ml) |
|            |                                |  | Oral                           |            |        | Air (μCi/ml)                        | Water (μCi/ml) |  |
|            |                                |  | Ingestion                      | Inhalation |        |                                     |                |  |
|            | ALI (μCi)                      | ALI (μCi)                                      | DAC (μCi/ml)                   |            |        |                                     |                |  |
| 59         | Praseodymium-142m <sup>2</sup> | 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-144 <sup>2</sup>  | 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-147 <sup>2</sup>  | 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-136 <sup>2</sup>     | W, all compounds except those given for Y      | 1E+4                           | 6E+4       | 2E-5   | 8E-8                                | 2E-4           | 2E-3                                   |
|            |                                | Y, oxides, hydroxides, carbides, and fluorides | -                              | 5E+4       | 2E-5   | 8E-8                                | -              | -                                      |
| 60         | Neodymium-138                  | W, see 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-139 <sup>2</sup>     | 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-149 <sup>2</sup>     | 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-151 <sup>2</sup>     | 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-141 <sup>2</sup>    | W, all compounds except those given for Y      | 5E+4                           | 2E+5       | 8E-5   | 3E-7                                | -              | -                                      |
|            |                                | St wall (6E+4)                                 | -                              | -          | -      | -                                   | 8E-4           | 8E-3                                   |
|            |                                | Y, oxides, hydroxides, carbides, and fluorides | -                              | 2E+5       | 7E-5   | 2E-7                                | -              | -                                      |
| 61         | Promethium-143                 | W, see 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 (5E+3)                                | -                              | -          | -      | 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-141m <sup>2</sup>     | 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                                   |

## Appendix B

| Atomic<br>No. | Radionuclide                | Class  | Table I<br>Occupational Values |                     |        | Table II<br>Effluent<br>Concentrations |                                | Table III<br>Releases to<br>Sewers                           |
|---------------|-----------------------------|--|--------------------------------|---------------------|--------|--|--------------------------------|--|
|               |                             |  | Col. 1                         | Col. 2              | Col. 3 | Col. 1                                 | Col. 2                         | Monthly<br>Average<br>Concentration<br>( $\mu\text{Ci/ml}$ ) |
|               |                             |  | Oral                           |                     |        | Air<br>( $\mu\text{Ci/ml}$ )           | Water<br>( $\mu\text{Ci/ml}$ ) |  |
|               |                             |  | Ingestion                      | Inhalation          |        |  |                                |  |
|               | ALI<br>( $\mu\text{Ci}$ )   | ALI<br>( $\mu\text{Ci}$ )                    | DAC<br>( $\mu\text{Ci/ml}$ )   |                     |        |  |                                |  |
| 62            | Samarium-142 <sup>2</sup>   | W, all compounds                             | 8E+3                           | 3E+4                | 1E-5   | 4E-8                                   | 1E-4                           | 1E-3   |
| 62            | Samarium-145                | W, all compounds                             | 6E+3                           | 5E+2                | 2E-7   | 7E-10                                  | 8E-5                           | 8E-4   |
| 62            | Samarium-146                | W, all compounds                             | 1E+1                           | 4E2                 | 1E-11  | -                                      | -                              | -  |
|               |                             |  | Bone surf<br>(3E+1)            | Bone surf<br>(6E-2) | -      | 9E-14                                  | 3E-7                           | 3E-6   |
| 62            | Samarium-147                | W, all compounds                             | 2E+1                           | 4E2                 | 2E-11  | -                                      | -                              | -  |
|               |                             |  | Bone surf<br>(3E+1)            | Bone surf<br>(7E-2) | -      | 1E-13                                  | 4E-7                           | 4E-6   |
| 62            | Samarium-151                | W, all compounds                             | 1E+4                           | 1E+2                | 4E-8   | -                                      | -                              | -  |
|               |                             |  | LLI wall<br>(1E+4)             | Bone surf<br>(2E+2) | -      | 2E-10                                  | 2E-4                           | 2E-3   |
| 62            | Samarium-153                | W, all compounds                             | 2E+3                           | 3E+3                | 1E-6   | 4E-9                                   | -                              | -  |
|               |                             |  | LLI wall<br>(2E+3)             | -                   | -      | -                                      | 3E-5                           | 3E-4   |
| 62            | Samarium-155 <sup>2</sup>   | W, all compounds                             | 6E+4                           | 2E+5                | 9E-5   | 3E-7                                   | -                              | -  |
|               |                             |  | St wall<br>(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<br>(12.62 h)   | W, all compounds                             | 3E+3                           | 8E+3                | 4E-6   | 1E-8                                   | 4E-5                           | 4E-4   |
| 63            | Europium-150<br>(34.2 y)    | W, all compounds                             | 8E+2                           | 2E+1                | 8E-9   | 3E-11                                  | 1E-5                           | 1E-4   |
| 63            | Europium-152m               | W, all compounds                             | 3E+3                           | 6E+3                | 3E-6   | 9E-9                                   | 4E-5                           | 4E-4   |
| 63            | Europium-152                | W, all compounds                             | 8E+2                           | 2E+1                | 1E-8   | 3E-11                                  | 1E-5                           | 1E-4   |
| 63            | Europium-154                | W, all compounds                             | 5E+2                           | 2E+1                | 8E-9   | 3E-11                                  | 7E-6                           | 7E-5   |
| 63            | Europium-155                | W, all compounds                             | 4E+3                           | 9E+1                | 4E-8   | -                                      | 5E-5                           | 5E-4   |
|               |                             |  | -                              | Bone surf<br>(1E+2) | -      | 2E-10                                  | -                              | -  |
| 63            | Europium-156                | W, all compounds                             | 6E+2                           | 5E+2                | 2E-7   | 6E-10                                  | 8E-6                           | 8E-5   |
| 63            | Europium-157                | W, all compounds                             | 2E+3                           | 5E+3                | 2E-6   | 7E-9                                   | 3E-5                           | 3E-4   |
| 63            | Europium-158 <sup>2</sup>   | W, all compounds                             | 2E+4                           | 6E+4                | 2E-5   | 8E-8                                   | 3E-4                           | 3E-3   |
| 64            | Gadolinium-145 <sup>2</sup> | D, all compounds except<br>those given for W | 5E+4                           | 2E+5                | 6E-5   | 2E-7                                   | -                              | -  |
|               |                             |  | St wall<br>(5E+4)              | -                   | -      | -                                      | 6E-4                           | 6E-3   |
|               |                             | W, oxides, hydroxides,<br>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<br>(2E+1)            | Bone surf<br>(2E+2) | -      | 2E-14                                  | 3E-7                           | 3E-6   |
|               |                             | W, see 145Gd                                 | -                              | 3E-2                | 1E-11  | -                                      | -                              | -  |
|               |                             |  | -                              | Bone surf<br>(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<br>(6E+2) | -      | 9E-10                                  | -                              | -  |
| 64            | Gadolinium-152              | W, see 145Gd                                 | -                              | 1E+3                | 5E-7   | 2E-9                                   | -                              | -  |
|               |                             | D, see 145Gd                                 | 2E+1                           | 1E-2                | 4E-12  | -                                      | -                              | -  |
|               |                             |  | Bone surf<br>(3E+1)            | Bone surf<br>(2E-2) | -      | 3E-14                                  | 4E-7                           | 4E-6   |
|               |                             | W, see 145Gd                                 | -                              | 4E-2                | 2E-11  | -                                      | -                              | -  |
| 64            | Gadolinium-153              | D, see 145Gd                                 | 5E+3                           | 1E+2                | 6E-8   | -                                      | 6E-5                           | 6E-4   |
|               |                             |  | -                              | Bone surf<br>(2E+2) | -      | 3E-10                                  | -                              | -  |
| 64            | Gadolinium-159              | W, see 145Gd                                 | -                              | 6E+2                | 2E-7   | 8E-10                                  | -                              | -  |
|               |                             | 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-147 <sup>2</sup>    | W, all compounds                             | 9E+3                           | 3E+4                | 1E-5   | 5E-8                                   | 1E-4                           | 1E-3   |
| 65            | Terbium-149                 | W, all compounds                             | 5E+3                           | 7E+2                | 3E-7   | 1E-9                                   | 7E-5                           | 7E-4   |
| 65            | Terbium-150                 | W, all compounds                             | 5E+3                           | 2E+4                | 9E-6   | 3E-8                                   | 7E-5                           | 7E-4   |
| 65            | Terbium-151                 | W, all compounds                             | 4E+3                           | 9E+3                | 4E-6   | 1E-8                                   | 5E-5                           | 5E-4   |
| 65            | Terbium-153                 | W, all compounds                             | 5E+3                           | 7E+3                | 3E-6   | 1E-8                                   | 7E-5                           | 7E-4   |
| 65            | Terbium-154                 | W, all compounds                             | 2E+3                           | 4E+3                | 2E-6   | 6E-9                                   | 2E-5                           | 2E-4   |
| 65            | Terbium-155                 | W, all compounds                             | 6E+3                           | 8E+3                | 3E-6   | 1E-8                                   | 8E-5                           | 8E-4   |

Appendix B

| Atomic No. | Radionuclide               | Class                                     | Table I<br>Occupational Values |                  |              | Table II<br>Effluent Concentrations |                | Table III<br>Releases to Sewers        |
|------------|----------------------------|---|--------------------------------|------------------|--------------|-------------------------------------|----------------|--|
|            |                            |   | Col. 1                         | Col. 2           | Col. 3       | Col. 1                              | Col. 2         | Monthly Average Concentration (μCi/ml) |
|            |                            |   | Oral                           |                  |              | Air (μCi/ml)                        | Water (μCi/ml) |  |
|            |                            |   | Ingestion (μCi)                | Inhalation (μCi) | DAC (μCi/ml) |                                     |                |  |
| 65         | Terbium-156m (5.0 h)       | W, all compounds                          | -                              | (8E-2)           | -            | 1E-13                               | -              | -                                      |
| 65         | Terbium-156m (24.4 h)      | W, all compounds                          | 2E+4                           | 3E+4             | 1E-5         | 4E-8                                | 2E-4           | 2E-3                                   |
| 65         | Terbium-156                | W, all compounds                          | 7E+3                           | 8E+3             | 3E-6         | 1E-8                                | 1E-4           | 1E-3                                   |
| 65         | Terbium-157                | W, all compounds                          | 1E+3                           | 1E+3             | 6E-7         | 2E-9                                | 1E-5           | 1E-4                                   |
| 65         | Terbium-158                | W, all compounds                          | 5E+4                           | 3E+2             | 1E-7         | -                                   | -              | -                                      |
| 65         | Terbium-160                | W, all compounds                          | LLI wall (5E+4)                | Bone surf (6E+2) | -            | 8E-10                               | 7E-4           | 7E-3                                   |
| 65         | Terbium-161                | W, all compounds                          | 1E+3                           | 2E+1             | 8E-9         | 3E-11                               | 2E-5           | 2E-4                                   |
| 65         | Terbium-161                | 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                                | -              | -                                      |
| 66         | Dysprosium-155             | W, all compounds                          | LLI wall (2E+3)                | -                | -            | -                                   | 3E-5           | 3E-4                                   |
| 66         | Dysprosium-157             | W, all compounds                          | 9E+3                           | 3E+4             | 1E-5         | 4E-8                                | 1E-4           | 1E-3                                   |
| 66         | Dysprosium-159             | W, all compounds                          | 2E+4                           | 6E+4             | 3E-5         | 9E-8                                | 3E-4           | 3E-3                                   |
| 66         | Dysprosium-165             | W, all compounds                          | 1E+4                           | 2E+3             | 1E-6         | 3E-9                                | 2E-4           | 2E-3                                   |
| 66         | Dysprosium-166             | 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                                | -              | -                                      |
| 67         | Holmium-155 <sup>2</sup>   | W, all compounds                          | LLI wall (8E+2)                | -                | -            | -                                   | 1E-5           | 1E-4                                   |
| 67         | Holmium-157 <sup>2</sup>   | W, all compounds                          | 4E+4                           | 2E+5             | 6E-5         | 2E-7                                | 6E-4           | 6E-3                                   |
| 67         | Holmium-159 <sup>2</sup>   | W, all compounds                          | 3E+5                           | 1E+6             | 6E-4         | 2E-6                                | 4E-3           | 4E-2                                   |
| 67         | Holmium-161                | W, all compounds                          | 2E+5                           | 1E+6             | 4E-4         | 1E-6                                | 3E-3           | 3E-2                                   |
| 67         | Holmium-162m <sup>2</sup>  | W, all compounds                          | 1E+5                           | 4E+5             | 2E-4         | 6E-7                                | 1E-3           | 1E-2                                   |
| 67         | Holmium-162 <sup>2</sup>   | W, all compounds                          | 5E+4                           | 3E+5             | 1E-4         | 4E-7                                | 7E-4           | 7E-3                                   |
| 67         | Holmium-162 <sup>2</sup>   | W, all compounds                          | 5E+5                           | 2E+6             | 1E-3         | 3E-6                                | -              | -                                      |
| 67         | Holmium-164m <sup>2</sup>  | W, all compounds                          | St wall (8E+5)                 | -                | -            | -                                   | 1E-2           | 1E-1                                   |
| 67         | Holmium-1642               | 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                                | -              | -                                      |
| 67         | Holmium-166m               | W, all compounds                          | St wall (2E+5)                 | -                | -            | -                                   | 3E-3           | 3E-2                                   |
| 67         | Holmium-166                | 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                                | -              | -                                      |
| 67         | Holmium-167                | W, all compounds                          | LLI wall (9E+2)                | -                | -            | -                                   | 1E-5           | 1E-4                                   |
| 68         | Erbium-161                 | W, all compounds                          | 2E+4                           | 6E+4             | 2E-5         | 8E-8                                | 2E-4           | 2E-3                                   |
| 68         | Erbium-165                 | W, all compounds                          | 2E+4                           | 6E+4             | 3E-5         | 9E-8                                | 2E-4           | 2E-3                                   |
| 68         | Erbium-169                 | 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                                | -              | -                                      |
| 68         | Erbium-171                 | W, all compounds                          | LLI wall (4E+3)                | -                | -            | -                                   | 5E-5           | 5E-4                                   |
| 68         | Erbium-172                 | 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                                | -              | -                                      |
| 69         | Thulium-162 <sup>2</sup>   | W, all compounds                          | LLI wall (E+3)                 | -                | -            | -                                   | 2E-5           | 2E-4                                   |
| 69         | Thulium-166                | W, all compounds                          | 7E+4                           | 3E+5             | 1E-4         | 4E-7                                | -              | -                                      |
| 69         | Thulium-167                | W, all compounds                          | St wall (7E+4)                 | -                | -            | -                                   | 1E-3           | 1E-2                                   |
| 69         | Thulium-170                | W, all compounds                          | 4E+3                           | 1E+4             | 6E-6         | 2E-8                                | 6E-5           | 6E-4                                   |
| 69         | Thulium-170                | W, all compounds                          | 2E+3                           | 2E+3             | 8E-7         | 3E-9                                | -              | -                                      |
| 69         | Thulium-171                | W, all compounds                          | LLI wall (2E+3)                | -                | -            | -                                   | 3E-4           | -                                      |
| 69         | Thulium-171                | W, all compounds                          | 8E+2                           | 2E+2             | 9E-8         | 3E-10                               | -              | -                                      |
| 69         | Thulium-171                | W, all compounds                          | LLI wall (1E+3)                | -                | -            | -                                   | 1E-5           | 1E-4                                   |
| 69         | Thulium-172                | W, all compounds                          | 1E+4                           | 3E+2             | 1E-7         | -                                   | -              | -                                      |
| 69         | Thulium-172                | W, all compounds                          | LLI wall (1E+4)                | Bone surf (6E+2) | -            | 8E-10                               | 2E-4           | 2E-3                                   |
| 69         | Thulium-173                | W, all compounds                          | 7E+2                           | 1E+3             | 5E-7         | 2E-9                                | -              | -                                      |
| 69         | Thulium-175 <sup>2</sup>   | W, all compounds                          | LLI wall (8E+2)                | -                | -            | -                                   | 1E-5           | 1E-4                                   |
| 69         | Thulium-175 <sup>2</sup>   | W, all compounds                          | 4E+3                           | 1E+4             | 5E-6         | 2E-8                                | 6E-5           | 6E-4                                   |
| 69         | Thulium-175 <sup>2</sup>   | W, all compounds                          | 7E+4                           | 3E+5             | 1E-4         | 4E-7                                | -              | -                                      |
| 70         | Ytterbium-162 <sup>2</sup> | W, all compounds except those given for Y | St wall (9E+4)                 | -                | -            | -                                   | 1E-3           | 1E-2                                   |
| 70         | Ytterbium-166              | W, see 162Yb                              | 7E+4                           | 3E+5             | 1E-4         | 4E-7                                | 1E-3           | 1E-2                                   |
| 70         | Ytterbium-167 <sup>2</sup> | W, see 162Yb                              | -                              | 3E+5             | 1E-4         | 4E-7                                | -              | -                                      |
| 70         | Ytterbium-169              | W, see 162Yb                              | 1E+3                           | 2E+3             | 8E-7         | 3E-9                                | 2E-5           | 2E-4                                   |
| 70         | Ytterbium-169              | W, see 162Yb                              | -                              | 2E+3             | 8E-7         | 3E-9                                | -              | -                                      |
| 70         | Ytterbium-169              | W, see 162Yb                              | 3E+5                           | 8E+5             | 3E-4         | 1E-6                                | 4E-3           | 4E-2                                   |
| 70         | Ytterbium-169              | W, 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                                   |
| 70         | Ytterbium-169              | W, see 162Yb                              | -                              | 7E+2             | 3E-7         | 1E-9                                | -              | -                                      |

Appendix B

| Atomic<br>No. | Radionuclide               | Class   | Table I<br>Occupational Values  |                                  |                              | Table II<br>Effluent<br>Concentrations |                                | Table III<br>Releases to<br>Sewers                           |
|---------------|----------------------------|---|---------------------------------|----------------------------------|------------------------------|--|--------------------------------|--|
|               |                            |   | Col. 1                          | Col. 2                           | Col. 3                       | Col. 1                                 | Col. 2                         | Monthly<br>Average<br>Concentration<br>( $\mu\text{Ci/ml}$ ) |
|               |                            |   | Oral                            |                                  |                              | Air<br>( $\mu\text{Ci/ml}$ )           | Water<br>( $\mu\text{Ci/ml}$ ) |  |
|               |                            |   | Ingestion<br>( $\mu\text{Ci}$ ) | Inhalation<br>( $\mu\text{Ci}$ ) | DAC<br>( $\mu\text{Ci/ml}$ ) |  |                                |  |
| 70            | Ytterbium-175              | W, see 162Yb                                  | 3E+3<br>LLI wall<br>(3E+3)      | 4E+3                             | 1E-6                         | 5E-9                                   | -                              | -  |
|               |                            | Y, see 162Yb                                  | -                               | 3E+3                             | 1E-6                         | 5E-9                                   | -                              | 4E-4   |
| 70            | Ytterbium-177 <sup>2</sup> | 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-178 <sup>2</sup> | 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   |
|               |                            | Y, see 169Lu                                  | -                               | Bone surf<br>(5E+2)              | -                            | 6E-10                                  | -                              | -  |
|               |                            | W, see 169Lu                                  | 2E+3                            | 3E+2                             | 1E-7                         | 4E-10                                  | -                              | -  |
| 71            | Lutetium-174m              | W, see 169Lu                                  | 2E+3<br>LLI wall<br>(3E+3)      | 2E+2                             | 1E-7                         | -                                      | -                              | -  |
|               |                            | Y, see 169Lu                                  | -                               | Bone surf<br>(3E+2)              | -                            | 5E-10                                  | 4E-5                           | 4E-4   |
|               |                            | W, see 169Lu                                  | 5E+3                            | 2E+2                             | 9E-8                         | 3E-10                                  | -                              | -  |
|               |                            | Y, see 169Lu                                  | -                               | 1E+2                             | 5E-8                         | -                                      | 7E-5                           | 7E-4   |
|               |                            | W, see 169Lu                                  | -                               | Bone surf<br>(2E+2)              | -                            | 3E-10                                  | -                              | -  |
| 71            | Lutetium-176m              | W, see 169Lu                                  | 8E+3                            | 2E+2                             | 6E-8                         | 2E-10                                  | -                              | -  |
|               |                            | Y, see 169Lu                                  | -                               | 3E+4                             | 1E-5                         | 3E-8                                   | 1E-4                           | 1E-3   |
|               |                            | W, see 169Lu                                  | 7E+2                            | 2E+4                             | 9E-6                         | 3E-8                                   | -                              | -  |
|               |                            | Y, see 169Lu                                  | -                               | 5E+0                             | 2E-9                         | -                                      | 1E-5                           | 1E-4   |
| 71            | Lutetium-177m              | W, see 169Lu                                  | 7E+2                            | Bone surf<br>(1E+1)              | -                            | 2E-11                                  | -                              | -  |
|               |                            | Y, see 169Lu                                  | -                               | 8E+0                             | 3E-9                         | 1E-11                                  | -                              | -  |
|               |                            | W, see 169Lu                                  | 7E+2                            | 1E+2                             | 5E-8                         | -                                      | 1E-5                           | 1E-4   |
|               |                            | Y, see 169Lu                                  | -                               | Bone surf<br>(1E+2)              | -                            | 2E-10                                  | -                              | -  |
|               |                            | W, see 169Lu                                  | 2E+3                            | 8E+1                             | 3E-8                         | 1E-10                                  | -                              | -  |
| 71            | Lutetium-177               | W, see 169Lu                                  | 2E+3<br>LLI wall<br>(3E+3)      | 2E+3                             | 9E-7                         | 3E-9                                   | -                              | -  |
|               |                            | Y, see 169Lu                                  | -                               | 2E+3                             | 9E-7                         | -                                      | 4E-5                           | 4E-4   |
|               |                            | W, see 169Lu                                  | 5E+4                            | 2E+5                             | 8E-5                         | 3E-7                                   | -                              | -  |
| 71            | Lutetium-178m <sup>2</sup> | W, see 169Lu                                  | 5E+4<br>St. wall<br>(6E+4)      | -                                | -                            | -                                      | 8E-4                           | 8E-3   |
|               |                            | Y, see 169Lu                                  | -                               | 2E+5                             | 7E-5                         | 2E-7                                   | -                              | -  |
|               |                            | W, see 169Lu                                  | 4E+4                            | 1E+5                             | 5E-5                         | 2E-7                                   | -                              | -  |
|               |                            | Y, see 169Lu                                  | -                               | -                                | -                            | -                                      | 6E-4                           | 6E-3   |
|               |                            | W, see 169Lu                                  | 6E+3                            | 1E+5                             | 5E-5                         | 2E-7                                   | -                              | -  |
|               |                            | Y, see 169Lu                                  | -                               | 2E+4                             | 8E-6                         | 3E-8                                   | 9E-5                           | 9E-4   |
|               |                            | W, 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   |
|               |                            | W, see 170Hf                                  | -                               | Bone surf<br>(2E+1)              | -                            | 3E-11                                  | -                              | -  |
|               |                            | Y, see 170Hf                                  | -                               | 4E+1                             | 2E-8                         | -                                      | -                              | -  |
|               |                            | W, see 170Hf                                  | -                               | Bone surf<br>(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   |
|               |                            | W, see 170Hf                                  | -                               | Bone surf<br>(1E+3)              | -                            | 1E-9                                   | -                              | -  |
|               |                            | Y, see 170Hf                                  | -                               | 1E+3                             | 5E-7                         | 2E-9                                   | -                              | -  |

Appendix B

| Atomic No. | Radionuclide               | Class  | Table I<br>Occupational Values |                  |              | Table II<br>Effluent Concentrations |                | Table III<br>Releases to Sewers        |
|------------|----------------------------|--|--------------------------------|------------------|--------------|-------------------------------------|----------------|--|
|            |                            |  | Col. 1                         | Col. 2           | Col. 3       | Col. 1                              | Col. 2         | Monthly Average Concentration (μCi/ml) |
|            |                            |  | Oral                           |                  |              | Air (μCi/ml)                        | Water (μCi/ml) |  |
|            |                            |  | Ingestion (μCi)                | Inhalation (μCi) | DAC (μCi/ml) |                                     |                |  |
| 72         | Hafnium-177m <sup>2</sup>  | 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                                   |
|            |                            | W, see 170Hf   | -                              | Bone surf (2E+0) | -            | 3E-12                               | -              | -                                      |
|            |                            |  | -                              | 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                                   |
|            |                            | W, see 170Hf   | -                              | Bone surf (6E+2) | -            | 8E-10                               | -              | -                                      |
|            |                            |  | -                              | 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                                   |
|            |                            | W, see 170Hf   | -                              | Bone surf (4E+2) | -            | 6E-10                               | -              | -                                      |
|            |                            |  | -                              | 4E+2             | 2E-7         | 6E-10                               | -              | -                                      |
| 72         | Hafnium-182m <sup>2</sup>  | 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        | -                                   | -              | -                                      |
|            |                            | W, see 170Hf   | Bone surf (4E+2)               | Bone surf (2E+0) | -            | 2E-12                               | 5E-6           | 5E-5                                   |
|            |                            |  | -                              | 3E+0             | 1E-9         | -                                   | -              | -                                      |
|            |                            |  | -                              | Bone surf (7E+0) | -            | 1E-11                               | -              | -                                      |
| 72         | Hafnium-183 <sup>2</sup>   | 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-172 <sup>2</sup>  | W, all compounds except those given for Y                                      | 4E+4                           | 1E+5             | 5E-5         | 2E-7                                | 5E-4           | 5E-3                                   |
|            |                            | Y, elemental Ta, oxides, hydroxides, halides, carbides, nitrates, and nitrides | -                              | 1E+5             | 4E-5         | 1E-7                                | -              | -                                      |
| 73         | Tantalum-173               | W, see 172Ta   | 7E+3                           | 2E+4             | 8E-6         | 3E-8                                | 9E-5           | 9E-4                                   |
|            |                            | Y, see 172Ta   | -                              | 2E+4             | 7E-6         | 2E-8                                | -              | -                                      |
| 73         | Tantalum-174 <sup>2</sup>  | 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-182m <sup>2</sup> | W, see 172Ta   | 2E+5                           | 5E+5             | 2E-4         | 8E-7                                | -              | -                                      |
|            |                            | Y, see 172Ta   | St wall (2E+5)                 | -                | -            | -                                   | 3E-3           | 3E-2                                   |
|            |                            |  | -                              | 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                                | -              | -                                      |
|            |                            | Y, see 172Ta   | LLI wall (1E+3)                | -                | -            | -                                   | 2E-5           | 2E-4                                   |
|            |                            |  | -                              | 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-185 <sup>2</sup>  | 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-186 <sup>2</sup>  | W, see 172Ta   | 5E+4                           | 2E+5             | 1E-4         | 3E-7                                | -              | -                                      |
|            |                            | Y, see 172Ta   | St wall (7E+4)                 | -                | -            | -                                   | 1E-3           | 1E-2                                   |
|            |                            |  | -                              | 2E+5             | 9E-5         | 3E-7                                | -              | -                                      |
| 74         | Tungsten-176               | D, all compounds   | 1E+4                           | 5E+4             | 2E-5         | 7E-8                                | 1E-4           | 1E-3                                   |
| 74         | Tungsten-177               | D, all compounds   | 2E+4                           | 9E+4             | 4E-5         | 1E-7                                | 3E-4           | 3E-3                                   |
| 74         | Tungsten-178               | D, all compounds   | 5E+3                           | 2E+4             | 8E-6         | 3E-8                                | 7E-5           | 7E-4                                   |
| 74         | Tungsten-179 <sup>2</sup>  | D, all compounds   | 5E+5                           | 2E+6             | 7E-4         | 2E-6                                | 7E-3           | 7E-2                                   |
| 74         | Tungsten-181               | D, all compounds   | 2E+4                           | 3E+4             | 1E-5         | 5E-8                                | 2E-4           | 2E-3                                   |
| 74         | Tungsten-185               | D, all compounds   | 2E+3                           | 7E+3             | 3E-6         | 9E-9                                | -              | -                                      |
|            |                            |  | LLI wall (3E+3)                | -                | -            | -                                   | 4E-5           | 4E-4                                   |

## Appendix B

| Atomic No. | Radionuclide              | Class   | Table I<br>Occupational Values |                      |              | Table II<br>Effluent Concentrations |                | Table III<br>Releases to Sewers        |
|------------|---------------------------|---|--------------------------------|----------------------|--------------|-------------------------------------|----------------|--|
|            |                           |   | Col. 1                         | Col. 2               | Col. 3       | Col. 1                              | Col. 2         | Monthly Average Concentration (μCi/ml) |
|            |                           |   | Oral                           |                      |              | Air (μCi/ml)                        | Water (μCi/ml) |  |
|            |                           |   | Ingestion ALI (μCi)            | Inhalation ALI (μCi) | DAC (μCi/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-177 <sup>2</sup>  | D, all compounds except those given for W                       | 9E+4                           | 3E+5                 | 1E-4         | 4E-7                                | -              | -                                      |
|            |                           |   | St wall (1E+5)                 | -                    | -            | -                                   | 2E-3           | 2E-2                                   |
| 75         | Rhenium-178 <sup>2</sup>  | W, oxides, hydroxides, and nitrates<br>D, see 177Re             | -                              | 4E+5                 | 1E-4         | 5E-7                                | -              | -                                      |
|            |                           |   | 7E+4                           | 3E+5                 | 1E-4         | 4E-7                                | -              | -                                      |
|            |                           |   | St wall (1E+5)                 | -                    | -            | -                                   | 1E-3           | 1E-2                                   |
| 75         | Rhenium-181               | W, see 177Re<br>D, see 177Re                                    | -                              | 3E+5                 | 1E-4         | 4E-7                                | -              | -                                      |
|            |                           |   | 5E+3                           | 9E+3                 | 4E-6         | 1E-8                                | 7E-5           | 7E-4                                   |
| 75         | Rhenium-182 (12.7 h)      | W, see 177Re<br>D, see 177Re                                    | -                              | 9E+3                 | 4E-6         | 1E-8                                | -              | -                                      |
|            |                           |   | 7E+3                           | 1E+4                 | 5E-6         | 2E-8                                | 9E-5           | 9E-4                                   |
| 75         | Rhenium-182 (64.0 h)      | W, see 177Re<br>D, see 177Re                                    | -                              | 2E+4                 | 6E-6         | 2E-8                                | -              | -                                      |
|            |                           |   | 1E+3                           | 2E+3                 | 1E-6         | 3E-9                                | 2E-5           | 2E-4                                   |
| 75         | Rhenium-184m              | W, see 177Re<br>D, see 177Re                                    | -                              | 2E+3                 | 9E-7         | 3E-9                                | -              | -                                      |
|            |                           |   | 2E+3                           | 3E+3                 | 1E-6         | 4E-9                                | 3E-5           | 3E-4                                   |
| 75         | Rhenium-184               | W, see 177Re<br>D, see 177Re                                    | -                              | 4E+2                 | 2E-7         | 6E-10                               | -              | -                                      |
|            |                           |   | 2E+3                           | 4E+3                 | 1E-6         | 5E-9                                | 3E-5           | 3E-4                                   |
| 75         | Rhenium-186m              | W, see 177Re<br>D, see 177Re                                    | -                              | 1E+3                 | 6E-7         | 2E-9                                | -              | -                                      |
|            |                           |   | 1E+3                           | 2E+3                 | 7E-7         | -                                   | -              | -                                      |
|            |                           |   | St wall (2E+3)                 | St wall (2E+3)       | -            | 3E-9                                | 2E-5           | 2E-4                                   |
| 75         | Rhenium-186               | W, see 177Re<br>D, see 177Re                                    | -                              | 2E+2                 | 6E-8         | 2E-10                               | -              | -                                      |
|            |                           |   | 2E+3                           | 3E+3                 | 1E-6         | 4E-9                                | 3E-5           | 3E-4                                   |
| 75         | Rhenium-187               | W, see 177Re<br>D, see 177Re                                    | -                              | 2E+3                 | 7E-7         | 2E-9                                | -              | -                                      |
|            |                           |   | 6E+5                           | 8E+5                 | 4E-4         | -                                   | 8E-3           | 8E-2                                   |
|            |                           |   | -                              | St wall (9E+5)       | -            | 1E-6                                | -              | -                                      |
| 75         | Rhenium-188m <sup>2</sup> | W, see 177Re<br>D, see 177Re                                    | -                              | 1E+5                 | 4E-5         | 1E-7                                | -              | -                                      |
|            |                           |   | 8E+4                           | 1E+5                 | 6E-5         | 2E-7                                | 1E-3           | 1E-2                                   |
| 75         | Rhenium-188               | W, see 177Re<br>D, see 177Re                                    | -                              | 1E+5                 | 6E-5         | 2E-7                                | -              | -                                      |
|            |                           |   | 2E+3                           | 3E+3                 | 1E-6         | 4E-9                                | 2E-5           | 2E-4                                   |
| 75         | Rhenium-189               | W, see 177Re<br>D, see 177Re                                    | -                              | 3E+3                 | 1E-6         | 4E-9                                | -              | -                                      |
|            |                           |   | 3E+3                           | 5E+3                 | 2E-6         | 7E-9                                | 4E-5           | 4E-4                                   |
| 76         | Osmium-180 <sup>2</sup>   | W, see 177Re<br>D, all compounds except those given for W and Y | -                              | 4E+3                 | 2E-6         | 6E-9                                | -              | -                                      |
|            |                           |   | 1E+5                           | 4E+5                 | 2E-4         | 5E-7                                | 1E-3           | 1E-2                                   |
|            |                           | W, halides and nitrates   | -                              | 5E+5                 | 2E-4         | 7E-7                                | -              | -                                      |
| 76         | Osmium-181 <sup>2</sup>   | Y, oxides and hydroxides<br>D, see 180Os                        | -                              | 5E+5                 | 2E-4         | 6E-7                                | -              | -                                      |
|            |                           |   | 1E+4                           | 4E+4                 | 2E-5         | 6E-8                                | 2E-4           | 2E-3                                   |
|            |                           | W, see 180Os  | -                              | 5E+4                 | 2E-5         | 6E-8                                | -              | -                                      |
| 76         | Osmium-182                | Y, see 180Os<br>D, see 180Os                                    | -                              | 4E+4                 | 2E-5         | 6E-8                                | -              | -                                      |
|            |                           |   | 2E+3                           | 6E+3                 | 2E-6         | 8E-9                                | 3E-5           | 3E-4                                   |
|            |                           | W, see 180Os  | -                              | 4E+3                 | 2E-6         | 6E-9                                | -              | -                                      |
| 76         | Osmium-185                | Y, see 180Os<br>D, see 180Os                                    | -                              | 4E+3                 | 2E-6         | 6E-9                                | -              | -                                      |
|            |                           |   | 2E+3                           | 5E+2                 | 2E-7         | 7E-10                               | 3E-5           | 3E-4                                   |
|            |                           | W, see 180Os  | -                              | 8E+2                 | 3E-7         | 1E-9                                | -              | -                                      |
| 76         | Osmium-189m               | Y, see 180Os<br>D, see 180Os                                    | -                              | 8E+2                 | 3E-7         | 1E-9                                | -              | -                                      |
|            |                           |   | 8E+4                           | 2E+5                 | 1E-4         | 3E-7                                | 1E-3           | 1E-2                                   |
|            |                           | W, see 180Os  | -                              | 2E+5                 | 9E-5         | 3E-7                                | -              | -                                      |
| 76         | Osmium-191m               | Y, see 180Os<br>D, see 180Os                                    | -                              | 2E+5                 | 7E-5         | 2E-7                                | -              | -                                      |
|            |                           |   | 1E+4                           | 3E+4                 | 1E-5         | 4E-8                                | 2E-4           | 2E-3                                   |
|            |                           | W, see 180Os  | -                              | 2E+4                 | 8E-6         | 3E-8                                | -              | -                                      |
| 76         | Osmium-191                | Y, see 180Os<br>D, see 180Os                                    | -                              | 2E+4                 | 7E-6         | 2E-8                                | -              | -                                      |
|            |                           |   | 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                                | -              | -                                      |
| 76         | Osmium-193                | Y, see 180Os<br>D, see 180Os                                    | -                              | 1E+3                 | 6E-7         | 2E-9                                | -              | -                                      |
|            |                           |   | 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                                | -              | -                                      |
| 76         | Osmium-194                | Y, see 180Os<br>D, see 180Os                                    | -                              | 3E+3                 | 1E-6         | 4E-9                                | -              | -                                      |
|            |                           |   | 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                               | -              | -                                      |
| 77         | Iridium-182 <sup>2</sup>  | Y, see 180Os<br>D, all compounds except those given for W and Y | -                              | 8E+0                 | 3E-9         | 1E-11                               | -              | -                                      |
|            |                           |   | 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                                | -              | -                                      |

Appendix B

| Atomic<br>No. | Radionuclide               | Class  | Table I<br>Occupational Values |            |          | Table II<br>Effluent<br>Concentrations |          | Table III<br>Releases to<br>Sewers  |
|---------------|----------------------------|--|--------------------------------|------------|----------|--|----------|-------------------------------------|
|               |                            |  | Col. 1                         | Col. 2     | Col. 3   | Col. 1                                 | Col. 2   | Monthly<br>Average<br>Concentration |
|               |                            |  | Oral                           |            |          | Air                                    | Water    | (μCi/ml)                            |
|               |                            |  | Ingestion                      | Inhalation |          | (μCi/ml)                               | (μCi/ml) |                                     |
|               | ALI<br>(μCi)               | ALI<br>(μCi)                                       | DAC<br>(μCi/ml)                | (μCi/ml)   | (μCi/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<br>(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-190m <sup>2</sup>  | 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<br>(3E+4)                                 | -                              | -          | -        | -                                      | 4E-5     | 4E-4                                |
| 78            | Platinum-193               | D, all compounds                                   | 4E+4                           | 2E+4       | 1E-5     | 3E-8                                   | -        | -                                   |
|               |                            | LLI wall<br>(5E+4)                                 | -                              | -          | -        | -                                      | 6E-4     | 6E-3                                |
| 78            | Platinum-195m              | D, all compounds                                   | 2E+3                           | 4E+3       | 2E-6     | 6E-9                                   | -        | -                                   |
|               |                            | LLI wall<br>(2E+3)                                 | -                              | -          | -        | -                                      | 3E-5     | 3E-4                                |
| 78            | Platinum-197m <sup>2</sup> | D, all compounds                                   | 2E+4                           | 4E+4       | 2E-5     | 6E-8                                   | 2E-4     | 2E-3                                |
| 78            | Platinum-197               | D, all compounds                                   | 3E+3                           | 1E+4       | 4E-6     | 1E-8                                   | 4E-5     | 4E-4                                |
| 78            | Platinum-199 <sup>2</sup>  | D, all compounds                                   | 5E+4                           | 1E+5       | 6E-5     | 2E-7                                   | 7E-4     | 7E-3                                |
| 78            | Platinum-200               | D, all compounds                                   | 1E+3                           | 3E+3       | 1E-6     | 5E-9                                   | 2E-5     | 2E-4                                |
| 79            | Gold-193                   | D, all compounds except<br>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                                   | -        | -                                   |

## Appendix B

| Atomic<br>No. | Radionuclide               | Class   | Table I<br>Occupational Values         |   |                              | Table II<br>Effluent<br>Concentrations |                                | Table III<br>Releases to<br>Sewers                           |
|---------------|----------------------------|---|--|---|------------------------------|--|--------------------------------|--|
|               |                            |   | Col. 1                                 | Col. 2                                  | Col. 3                       | Col. 1                                 | Col. 2                         | Monthly<br>Average<br>Concentration<br>( $\mu\text{Ci/ml}$ ) |
|               |                            |   | Oral                                   |   |                              | Air<br>( $\mu\text{Ci/ml}$ )           | Water<br>( $\mu\text{Ci/ml}$ ) |  |
|               |                            |   | Ingestion<br>ALI<br>( $\mu\text{Ci}$ ) | Inhalation<br>ALI<br>( $\mu\text{Ci}$ ) | DAC<br>( $\mu\text{Ci/ml}$ ) |  |                                |  |
| 79            | Gold-198                   | D, see 193Au<br>W, see 193Au<br>Y, see 193Au                      | 1E+3                                   | 4E+3                                    | 2E-6                         | 5E-9                                   | 2E-5                           | 2E-4   |
| 79            | Gold-199                   | D, see 193Au  | 3E+3                                   | 9E+3                                    | 4E-6                         | 1E-8                                   | -                              | -  |
|               |                            | LLI wall<br>(3E+3)  | -                                      | -                                       | -                            | -                                      | 4E-5                           | 4E-4   |
| 79            | Gold-200m                  | W, see 193Au<br>Y, see 193Au<br>D, see 193Au                      | 1E+3                                   | 4E+3                                    | 1E-6                         | 5E-9                                   | 2E-5                           | 2E-4   |
| 79            | Gold-200 <sup>2</sup>      | W, see 193Au<br>D, see 193Au                                      | 3E+4                                   | 6E+4                                    | 3E-5                         | 9E-8                                   | 4E-4                           | 4E-3   |
| 79            | Gold-201 <sup>2</sup>      | W, see 193Au<br>Y, see 193Au<br>D, see 193Au                      | 7E+4                                   | 2E+5                                    | 9E-5                         | 3E-7                                   | -                              | -  |
|               |                            | St wall<br>(9E+4)   | -                                      | -                                       | -                            | -                                      | 1E-3                           | 1E-2   |
| 80            | Mercury-193m               | W, see 193Au<br>Y, see 193Au<br>Vapor<br>Organic D<br>D, sulfates | 4E+3                                   | 1E+4                                    | 5E-6                         | 2E-8                                   | 6E-5                           | 6E-4   |
|               |                            | W, oxides, hydroxides,<br>halides, nitrates, and<br>sulfides      | 3E+3                                   | 9E+3                                    | 4E-6                         | 1E-8                                   | 4E-5                           | 4E-4   |
| 80            | Mercury-193                | Vapor<br>Organic D<br>D, see 193mHg                               | 2E+4                                   | 6E+4                                    | 3E-5                         | 9E-8                                   | 3E-4                           | 3E-3   |
| 80            | Mercury-194                | W, see 193mHg<br>Vapor<br>Organic D<br>D, see 193mHg              | 2E+4                                   | 4E+4                                    | 2E-5                         | 6E-8                                   | 2E-4                           | 2E-3   |
| 80            | Mercury-195m               | W, see 193mHg<br>Vapor<br>Organic D<br>D, see 193mHg              | 2E+1                                   | 3E+1                                    | 1E-8                         | 4E-11                                  | 2E-7                           | 2E-6   |
| 80            | Mercury-195                | W, see 193mHg<br>Vapor<br>Organic D<br>D, see 193mHg              | 8E+2                                   | 4E+1                                    | 2E-8                         | 6E-11                                  | 1E-5                           | 1E-4   |
| 80            | Mercury-197m               | W, see 193mHg<br>Vapor<br>Organic D<br>D, see 193mHg              | -                                      | 1E+2                                    | 5E-8                         | 2E-10                                  | -                              | -  |
| 80            | Mercury-197                | W, see 193mHg<br>Vapor<br>Organic D<br>D, see 193mHg              | 3E+3                                   | 6E+3                                    | 3E-6                         | 8E-9                                   | 4E-5                           | 4E-4   |
| 80            | Mercury-199m <sup>2</sup>  | W, see 193mHg<br>Vapor<br>Organic D                               | 2E+3                                   | 5E+3                                    | 2E-6                         | 7E-9                                   | 3E-5                           | 3E-4   |
| 80            | Mercury-203                | W, see 193mHg<br>Vapor<br>Organic D<br>D, see 193mHg              | 5E+2                                   | 8E+2                                    | 3E-7                         | 1E-9                                   | 7E-6                           | 7E-5   |
| 81            | Thallium-194m <sup>2</sup> | D, all compounds  | 5E+4                                   | 2E+5                                    | 6E-5                         | 2E-7                                   | -                              | -  |
| 81            | Thallium-194 <sup>2</sup>  | D, all compounds  | 3E+5                                   | 6E+5                                    | 2E-4                         | 8E-7                                   | -                              | -  |
| 81            | Thallium-195 <sup>2</sup>  | D, all compounds  | 6E+4                                   | 1E+5                                    | 5E-5                         | 2E-7                                   | 9E-4                           | 9E-3   |
| 81            | Thallium-197               | D, all compounds  | 7E+4                                   | 1E+5                                    | 5E-5                         | 2E-7                                   | 1E-3                           | 1E-2   |
| 81            | Thallium-198m <sup>2</sup> | D, all compounds  | 3E+4                                   | 5E+4                                    | 2E-5                         | 8E-8                                   | 4E-4                           | 4E-3   |
| 81            | Thallium-198               | D, all compounds  | 2E+4                                   | 3E+4                                    | 1E-5                         | 5E-8                                   | 3E-4                           | 3E-3   |
| 81            | Thallium-199               | D, all compounds  | 6E+4                                   | 8E+4                                    | 4E-5                         | 1E-7                                   | 9E-4                           | 9E-3   |
| 81            | Thallium-200               | D, all compounds  | 8E+3                                   | 1E+4                                    | 5E-6                         | 2E-8                                   | 1E-4                           | 1E-3   |
| 81            | Thallium-201               | D, all compounds  | 2E+4                                   | 2E+4                                    | 9E-6                         | 3E-8                                   | 2E-4                           | 2E-3   |
| 81            | Thallium-202               | D, all compounds  | 4E+3                                   | 5E+3                                    | 2E-6                         | 7E-9                                   | 5E-5                           | 5E-4   |
| 81            | Thallium-204               | D, all compounds  | 2E+3                                   | 2E+3                                    | 9E-7                         | 3E-9                                   | 2E-5                           | 2E-4   |
| 82            | Lead-195m <sup>2</sup>     | D, all compounds  | 6E+4                                   | 2E+5                                    | 8E-5                         | 3E-7                                   | 8E-4                           | 8E-3   |
| 82            | Lead-198                   | D, all compounds  | 3E+4                                   | 6E+4                                    | 3E-5                         | 9E-8                                   | 4E-4                           | 4E-3   |
| 82            | Lead-1992                  | D, all compounds  | 2E+4                                   | 7E+4                                    | 3E-5                         | 1E-7                                   | 3E-4                           | 3E-3   |

Appendix B

| Atomic No. | Radionuclide              | Class                                     | Table I             |                  |              | Table II                |                | Table III                              |
|------------|---------------------------|---|---------------------|------------------|--------------|-------------------------|----------------|--|
|            |                           |   | Occupational Values |                  |              | Effluent Concentrations |                | Releases to Sewers                     |
|            |                           |   | Col. 1              | Col. 2           | Col. 3       | Col. 1                  | Col. 2         | Monthly Average Concentration (μCi/ml) |
|            |                           |   | Oral                |                  |              | Air (μCi/ml)            | Water (μCi/ml) |  |
| Ingestion  |                           | Inhalation                                |                     |                  |              |                         |                |  |
|            |                           |   | ALI (μCi)           | ALI (μCi)        | DAC (μCi/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                   | 7E-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 (1E+0)    | Bone surf (4E-1) | -            | 6E-13                   | 1E-8           | 1E-7                                   |
| 82         | Lead-211 <sup>2</sup>     | D, all compounds                          | 1E+4                | 6E+2             | 3E-7         | 9E-10                   | 2E-4           | 2E-3                                   |
| 82         | Lead-212                  | D, all compounds                          | 8E+1                | 3E+1             | 1E-8         | 5E-11                   | -              | -                                      |
|            |                           |   | Bone surf (1E+2)    | -                | -            | -                       | 2E-6           | 2E-5                                   |
| 82         | Lead-214 <sup>2</sup>     | D, all compounds                          | 9E+3                | 8E+2             | 3E-7         | 1E-9                    | 1E-4           | 1E-3                                   |
| 83         | Bismuth-200 <sup>2</sup>  | D, nitrates                               | 3E+4                | 8E+4             | 4E-5         | 1E-7                    | 4E-4           | 4E-3                                   |
|            |                           | W, all other compounds                    | -                   | 1E+5             | 4E-5         | 1E-7                    | -              | -                                      |
| 83         | Bismuth-201 <sup>2</sup>  | D, see 200Bi                              | 1E+4                | 3E+4             | 1E-5         | 4E-8                    | 2E-4           | 2E-3                                   |
|            |                           | W, see 200Bi                              | -                   | 4E+4             | 2E-5         | 5E-8                    | -              | -                                      |
| 83         | Bismuth-202 <sup>2</sup>  | 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 (6E+1)      | Kidneys (6E+0)   | -            | 9E-12                   | 8E-7           | 8E-6                                   |
| 83         | Bismuth-210               | W, see 200Bi                              | -                   | 7E-1             | 3E-10        | 9E-13                   | -              | -                                      |
|            |                           | 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-212 <sup>2</sup>  | 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-213 <sup>2</sup>  | 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-214 <sup>2</sup>  | 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-203 <sup>2</sup> | 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-205 <sup>2</sup> | 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-207 <sup>2</sup> | 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 1.0 WLM)     | (or 1.0 WL)  | -                       | -              | -                                      |
| 86         | Radon-222                 | With daughters removed                    | -                   | 1E+4             | 4E-6         | 1E-8                    | -              | -                                      |
|            |                           | With daughters present                    | -                   | 1E+2             | 3E-8         | 1E-10                   | -              | -                                      |
|            |                           |   | -                   | (or 4 WLM)       | (or 0.33 WL) | -                       | -              | -                                      |
| 87         | Francium-222 <sup>2</sup> | D, all compounds                          | 2E+3                | 5E+2             | 2E-7         | 6E-10                   | 3E-5           | 3E-4                                   |
| 87         | Francium-223 <sup>2</sup> | D, all compounds                          | 6E+2                | 8E+2             | 3E-7         | 1E-9                    | 8E-6           | 8E-5                                   |
| 88         | Radium-223                | W, all compounds                          | 5E+0                | 7E-1             | 3E-10        | 9E-13                   | -              | -                                      |
|            |                           |   | Bone surf (9E+0)    | -                | -            | -                       | 1E-7           | 1E-6                                   |
| 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                                   |

Appendix B

| Atomic<br>No. | Radionuclide                  | Class  | Table I<br>Occupational Values |                     |                       | Table II<br>Effluent<br>Concentrations |                         | Table III<br>Releases to<br>Sewers                    |
|---------------|-------------------------------|--|--------------------------------|---------------------|-----------------------|--|-------------------------|---|
|               |                               |  | Col. 1                         | Col. 2              | Col. 3                | Col. 1                                 | Col. 2                  | Monthly<br>Average<br>Concentration<br>( $\mu$ Ci/ml) |
|               |                               |  | Oral                           |                     |                       | Air<br>( $\mu$ Ci/ml)                  | Water<br>( $\mu$ Ci/ml) |   |
|               |                               |  | Ingestion                      |                     | Inhalation            |  |                         |   |
|               |                               |  | ALI<br>( $\mu$ Ci)             | ALI<br>( $\mu$ Ci)  | DAC<br>( $\mu$ Ci/ml) |  |                         |   |
| 88            | Radium-226                    | W, all compounds                                   | 2E+0                           | 6E-1                | 3E-10                 | 9E-13                                  | -                       | -   |
|               |                               |  | Bone surf<br>(5E+0)            | -                   | -                     | -                                      | 6E-8                    | 6E-7  |
| 88            | Radium-227 <sup>2</sup>       | W, all compounds                                   | 2E+4                           | 1E+4                | 6E-6                  | -                                      | -                       | -   |
|               |                               |  | Bone surf<br>(2E+4)            | Bone surf<br>(2E+4) | -                     | 3E-8                                   | 3E-4                    | 3E-3  |
| 88            | Radium-228                    | W, all compounds                                   | 2E+0                           | 1E+0                | 5E-10                 | 2E-12                                  | -                       | -   |
|               |                               |  | Bone surf<br>(4E+0)            | -                   | -                     | -                                      | 6E-8                    | 6E-7  |
| 89            | Actinium-224                  | D, all compounds except<br>those given for W and Y | 2E+3                           | 3E+1                | 1E-8                  | -                                      | -                       | -   |
|               |                               |  | LLI wall<br>(2E+3)             | Bone surf<br>(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                                  | -                       | -   |
|               |                               | D, see 224Ac                                       | 5E+1                           | 3E-1                | 1E-10                 | -                                      | -                       | -   |
| 89            | Actinium-225                  | D, see 224Ac                                       | LLI wall<br>(5E+1)             | Bone surf<br>(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                                  | -                       | -   |
|               |                               | D, see 224Ac                                       | 1E+2                           | 3E+0                | 1E-9                  | -                                      | -                       | -   |
| 89            | Actinium-226                  | D, see 224Ac                                       | LLI wall<br>(1E+2)             | Bone surf<br>(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                                  | -                       | -   |
|               |                               | D, see 224Ac                                       | 2E-1                           | 4E-4                | 2E-13                 | -                                      | -                       | -   |
|               |                               |  | Bone surf<br>(4E-1)            | Bone surf<br>(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<br>(2E+1) | -                     | 2E-11                                  | -                       | -   |
|               |                               | W, see 224Ac                                       | -                              | 4E+1                | 2E-8                  | -                                      | -                       | -   |
|               |                               |  | -                              | Bone surf<br>(6E+1) | -                     | 8E-11                                  | -                       | -   |
| 90            | Thorium-226 <sup>2</sup>      | Y, see 224Ac                                       | -                              | 4E+1                | 2E-8                  | 6E-11                                  | -                       | -   |
|               |                               | W, all compounds except<br>those given for Y       | 5E+3                           | 2E+2                | 6E-8                  | 2E-10                                  | -                       | -   |
|               |                               |  | St wall<br>(5E+3)              | -                   | -                     | -                                      | 7E-5                    | 7E-4  |
| 90            | Thorium-227                   | Y, oxides and hydroxides                           | 1E+2                           | 1E+2                | 6E-8                  | 2E-10                                  | -                       | -   |
|               |                               | W, see 226Th                                       | -                              | 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<br>(1E+1)            | Bone surf<br>(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<br>(1E+0)            | Bone surf<br>(2E-3) | -                     | 3E-15                                  | 2E-8                    | 2E-7  |
|               |                               | Y, see 226Th                                       | -                              | 2E-3                | 1E-12                 | -                                      | -                       | -   |
|               |                               |  | -                              | Bone surf<br>(3E-3) | -                     | 4E-15                                  | -                       | -   |
| 90            | Thorium-230                   | W, see 226Th                                       | 4E+0                           | 6E-3                | 3E-12                 | -                                      | -                       | -   |
|               |                               |  | Bone surf<br>(9E+0)            | Bone surf<br>(2E-2) | -                     | 2E-14                                  | 1E-7                    | 1E-6  |
|               |                               | Y, see 226Th                                       | -                              | 2E-2                | 6E-12                 | -                                      | -                       | -   |
|               |                               |  | -                              | Bone surf<br>(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<br>(2E+0)            | Bone surf<br>(3E-3) | -                     | 4E-15                                  | 3E-8                    | 3E-7  |
|               |                               | Y, see 226Th                                       | -                              | 3E-3                | 1E-12                 | -                                      | -                       | -   |
|               |                               |  | -                              | Bone surf<br>(4E-3) | -                     | 6E-15                                  | -                       | -   |
| 90            | Thorium-234                   | W, see 226Th                                       | 3E+2                           | 2E+2                | 8E-8                  | 3E-10                                  | -                       | -   |
|               |                               |  | LLI wall<br>(4E+2)             | -                   | -                     | -                                      | 5E-6                    | 5E-5  |
|               |                               | Y, see 226Th                                       | -                              | 2E+2                | 6E-8                  | 2E-10                                  | -                       | -   |
| 91            | Protactinium-227 <sup>2</sup> | W, all compounds except<br>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                                  | -                       | -   |

Appendix B

| Atomic No. | Radionuclide             | Class   | Table I             |                  |              | Table II                |                | Table III                              |
|------------|--------------------------|---|---------------------|------------------|--------------|-------------------------|----------------|--|
|            |                          |   | Occupational Values |                  |              | Effluent Concentrations |                | Releases to Sewers                     |
|            |                          |   | Col. 1              | Col. 2           | Col. 3       | Col. 1                  | Col. 2         | Monthly Average Concentration (μCi/ml) |
|            |                          |   | Oral                |                  |              | Air (μCi/ml)            | Water (μCi/ml) |  |
| Ingestion  |                          | Inhalation  |                     |                  |              |                         |                |  |
|            |                          |   | ALI (μCi)           | ALI (μCi)        | DAC (μCi/ml) |                         |                |  |
| 91         | Protactinium-228         | W, see 227Pa  | 1E+3                | 1E+1             | 5E-9         | -                       | 2E-5           | 2E-4                                   |
|            |                          |   |                     | Bone surf (2E+1) | -            | 3E-11                   | -              | -                                      |
| 91         | Protactinium-230         | Y, see 227Pa<br>W, see 227Pa  | 6E+2                | 1E+1             | 5E-9         | 2E-11                   | -              | -                                      |
|            |                          |   |                     | 5E+0             | 2E-9         | 7E-12                   | -              | -                                      |
|            |                          |   | Bone surf (9E+2)    | -                | -            | -                       | 1E-5           | 1E-4                                   |
| 91         | Protactinium-231         | Y, see 227Pa<br>W, see 227Pa  | 2E-1                | 4E+0             | 1E-9         | 5E-12                   | -              | -                                      |
|            |                          |   |                     | 2E-3             | 6E-13        | -                       | -              | -                                      |
|            |                          |   | Bone surf (5E-1)    | Bone surf (4E-3) | -            | 6E-15                   | 6E-9           | 6E-8                                   |
|            |                          | Y, see 227Pa  | -                   | 4E-3             | 2E-12        | -                       | -              | -                                      |
| 91         | Protactinium-232         | W, see 227Pa  | 1E+3                | Bone surf (6E-3) | -            | 8E-15                   | -              | -                                      |
|            |                          |   |                     | 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                                   |
| 91         | Protactinium-234         | Y, see 227Pa<br>W, see 227Pa  | 2E+3                | 6E+2             | 2E-7         | 8E-10                   | -              | -                                      |
|            |                          | Y, see 227Pa  | -                   | 8E+3             | 3E-6         | 1E-8                    | 3E-5           | 3E-4                                   |
| 92         | Uranium-230              | D, UF, UOF, UO(NO)  | 4E+0                | 7E+3             | 3E-6         | 9E-9                    | -              | -                                      |
|            |                          |   |                     | 4E-1             | 2E-10        | -                       | -              | -                                      |
|            |                          |   | Bone surf (6E+0)    | Bone surf (6E-1) | -            | 8E-13                   | 8E-8           | 8E-7                                   |
|            |                          |   |                     | 4E-1             | 1E-10        | 5E-13                   | -              | -                                      |
| 92         | Uranium-231              | W, UO, UF, UCI<br>Y, UO, UO<br>D, see 230U                              | 5E+3                | 3E-1             | 1E-10        | 4E-13                   | -              | -                                      |
|            |                          |   |                     | 8E+3             | 3E-6         | 1E-8                    | -              | -                                      |
|            |                          |   | LLI wall (4E+3)     | -                | -            | -                       | 6E-5           | 6E-4                                   |
|            |                          |   |                     | 6E+3             | 2E-6         | 8E-9                    | -              | -                                      |
| 92         | Uranium-232              | W, see 230U<br>Y, see 230U<br>D, see 230U                               | 2E+0                | 5E+3             | 2E-6         | 6E-9                    | -              | -                                      |
|            |                          |   |                     | 2E-1             | 9E-11        | -                       | -              | -                                      |
|            |                          |   | Bone surf (4E+0)    | Bone surf (4E-1) | -            | 6E-13                   | 6E-8           | 6E-7                                   |
|            |                          |   |                     | 4E-1             | 2E-10        | 5E-13                   | -              | -                                      |
| 92         | Uranium-233              | W, see 230U<br>Y, see 230U<br>D, see 230U                               | 1E+1                | 8E-3             | 3E-12        | 1E-14                   | -              | -                                      |
|            |                          |   |                     | 1E+0             | 5E-10        | -                       | -              | -                                      |
|            |                          |   | Bone surf (2E+1)    | Bone surf (2E+0) | -            | 3E-12                   | 3E-7           | 3E-6                                   |
|            |                          |   |                     | 7E-1             | 3E-10        | 1E-12                   | -              | -                                      |
| 92         | Uranium-234 <sup>3</sup> | W, see 230U<br>Y, see 230U<br>D, see 230U                               | 1E+1                | 4E-2             | 2E-11        | 5E-14                   | -              | -                                      |
|            |                          |   |                     | 1E+0             | 5E-10        | -                       | -              | -                                      |
|            |                          |   | Bone surf (2E+1)    | Bone surf (2E+0) | -            | 3E-12                   | 3E-7           | 3E-6                                   |
|            |                          |   |                     | 7E-1             | 3E-10        | 1E-12                   | -              | -                                      |
| 92         | Uranium-235 <sup>3</sup> | W, see 230U<br>Y, see 230U<br>D, see 230U                               | 1E+1                | 4E-2             | 2E-11        | 5E-14                   | -              | -                                      |
|            |                          |   |                     | 1E+0             | 6E-10        | -                       | -              | -                                      |
|            |                          |   | Bone surf (2E+1)    | Bone surf (2E+0) | -            | 3E-12                   | 3E-7           | 3E-6                                   |
|            |                          |   |                     | 8E-1             | 3E-10        | 1E-12                   | -              | -                                      |
| 92         | Uranium-236              | W, see 230U<br>Y, see 230U<br>D, see 230U                               | 1E+1                | 4E-2             | 2E-11        | 6E-14                   | -              | -                                      |
|            |                          |   |                     | 1E+0             | 5E-10        | -                       | -              | -                                      |
|            |                          |   | Bone surf (2E+1)    | Bone surf (2E+0) | -            | 3E-12                   | 3E-7           | 3E-6                                   |
|            |                          |   |                     | 8E-1             | 3E-10        | 1E-12                   | -              | -                                      |
| 92         | Uranium-237              | W, see 230U<br>Y, see 230U<br>D, see 230U                               | 2E+3                | 4E-2             | 2E-11        | 6E-14                   | -              | -                                      |
|            |                          |   |                     | 3E+3             | 1E-6         | 4E-9                    | -              | -                                      |
|            |                          |   | LLI wall (2E+3)     | -                | -            | -                       | 3E-5           | 3E-4                                   |
|            |                          |   |                     | 2E+3             | 7E-7         | 2E-9                    | -              | -                                      |
|            |                          |   |                     | 2E+3             | 6E-7         | 2E-9                    | -              | -                                      |
| 92         | Uranium-238 <sup>3</sup> | W, see 230U<br>Y, see 230U<br>D, see 230U                               | 1E+1                | 1E+0             | 6E-10        | -                       | -              | -                                      |
|            |                          |   | Bone surf (2E+1)    | Bone surf (2E+0) | -            | 3E-12                   | 3E-7           | 3E-6                                   |
|            |                          |   |                     | 8E-1             | 3E-10        | 1E-12                   | -              | -                                      |
| 92         | Uranium-239 <sup>2</sup> | W, see 230U<br>Y, see 230U<br>D, see 230U                               | 7E+4                | 4E-2             | 2E-11        | 6E-14                   | -              | -                                      |
|            |                          |   |                     | 2E+5             | 8E-5         | 3E-7                    | 9E-4           | 9E-3                                   |
|            |                          |   |                     | 2E+5             | 7E-5         | 2E-7                    | -              | -                                      |
| 92         | Uranium-240              | W, see 230U<br>Y, see 230U<br>W, see 230U<br>D, see 230U<br>Y, see 230U | 1E+3                | 2E+5             | 6E-5         | 2E-7                    | -              | -                                      |
|            |                          |   |                     | 4E+3             | 2E-6         | 5E-9                    | 2E-5           | 2E-4                                   |
|            |                          |   |                     | 3E+3             | 1E-6         | 4E-9                    | -              | -                                      |
|            |                          |   |                     | 2E+3             | 1E-6         | 3E-9                    | -              | -                                      |

## Appendix B

| Atomic No. | Radionuclide                 | Class                                    | Table I<br>Occupational Values |                  |              | Table II<br>Effluent Concentrations |                | Table III<br>Releases to Sewers        |
|------------|------------------------------|--|--------------------------------|------------------|--------------|-------------------------------------|----------------|--|
|            |                              |  | Col. 1                         | Col. 2           | Col. 3       | Col. 1                              | Col. 2         | Monthly Average Concentration (μCi/ml) |
|            |                              |  | Oral                           |                  |              | Air (μCi/ml)                        | Water (μCi/ml) |  |
|            |                              |  | ALI (μCi)                      | ALI (μCi)        | DAC (μCi/ml) |                                     |                |  |
| 92         | Uranium-natural <sup>3</sup> | D, see 230U                              | 1E+1                           | 1E+0             | 5E-10        | -                                   | -              | -                                      |
|            |                              |  | Bone surf (2E+1)               | Bone surf (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-232 <sup>2</sup>   | W, all compounds                         | 1E+5                           | 2E+3             | 7E-7         | -                                   | 2E-3           | 2E-2                                   |
|            |                              |  | -                              | Bone surf (5E+2) | -            | 6E-9                                | -              | -                                      |
| 93         | Neptunium-233 <sup>2</sup>   | W, all compounds                         | 8E+5                           | 3E+6             | 1E-3         | 4E-6                                | 1E-2           | 1E-1                                   |
| 93         | Neptunium-234                | W, all compounds                         | 2E+3                           | 3E+3             | 1E-6         | 4E-9                                | 3E-5           | 3E-4                                   |
| 93         | Neptunium-235                | W, all compounds                         | 2E+4                           | 8E+2             | 3E-7         | -                                   | -              | -                                      |
|            |                              |  | LLI wall (2E+4)                | Bone surf (1E+3) | -            | 2E-9                                | 3E-4           | 3E-3                                   |
| 93         | Neptunium-236 (1.15E+5 y)    | W, all compounds                         | 3E+0                           | 2E-2             | 9E-12        | -                                   | -              | -                                      |
|            |                              |  | Bone surf (6E+0)               | Bone surf (5E-2) | -            | 8E-14                               | 9E-8           | 9E-7                                   |
| 93         | Neptunium-236 (22.5 h)       | W, all compounds                         | 3E+3                           | 3E+1             | 1E-8         | -                                   | -              | -                                      |
|            |                              |  | Bone surf (4E+3)               | Bone surf (7E+1) | -            | 1E-10                               | 5E-5           | 5E-4                                   |
| 93         | Neptunium-237                | W, all compounds                         | 5E-1                           | 4E-3             | 2E-12        | -                                   | -              | -                                      |
|            |                              |  | Bone surf (1E+0)               | Bone surf (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-240 <sup>2</sup>   | W, all compounds                         | 2E+4                           | 8E+4             | 3E-5         | 1E-7                                | 3E-4           | 3E-3                                   |
| 94         | Plutonium-234                | W, all compounds except PuO <sub>2</sub> | 8E+3                           | 2E+2             | 9E-8         | 3E-10                               | 1E-4           | 1E-3                                   |
|            |                              | Y, PuO <sub>2</sub>                      | -                              | 2E+2             | 8E-8         | 3E-10                               | -              | -                                      |
| 94         | Plutonium-235 <sup>2</sup>   | 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 (4E+0)               | Bone surf (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 (2E+0)               | Bone surf (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 (1E+0)               | Bone surf (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 (1E+0)               | Bone surf (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 (7E+1)               | Bone surf (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 (1E+0)               | Bone surf (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 (2E+0)               | Bone surf (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                               | -              | -                                      |

| Atomic No. | Radionuclide                 | Class                                     | Table I<br>Occupational Values |                  |        | Table II<br>Effluent Concentrations |                | Table III<br>Releases to Sewers        |
|------------|------------------------------|---|--------------------------------|------------------|--------|-------------------------------------|----------------|--|
|            |                              |   | Col. 1                         | Col. 2           | Col. 3 | Col. 1                              | Col. 2         | Monthly Average Concentration (μCi/ml) |
|            |                              |   | Oral                           |                  |        | Air (μCi/ml)                        | Water (μCi/ml) |  |
|            |                              |   | Ingestion                      | Inhalation       |        |                                     |                |  |
| ALI (μCi)  | ALI (μCi)                    | DAC (μCi/ml)                              |                                |                  |        |                                     |                |  |
| 95         | Americium-237 <sup>2</sup>   | W, all compounds                          | 8E+4                           | 3E+5             | 1E-4   | 4E-7                                | 1E-3           | 1E-2                                   |
| 95         | Americium-238 <sup>2</sup>   | W, all compounds                          | 4E+4                           | 3E+3             | 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 (1E+0)               | Bone surf (1E-2) | -      | 2E-14                               | 2E-8           | 2E-7                                   |
| 95         | Americium-242m               | W, all compounds                          | 8E-1                           | 6E-3             | 3E-12  | -                                   | -              | -                                      |
|            |                              |   | Bone surf (1E+0)               | Bone surf (1E-2) | -      | 2E-14                               | 2E-8           | 2E-7                                   |
| 95         | Americium-242                | W, all compounds                          | 4E+3                           | 8E+1             | 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 (1E+0)               | Bone surf (1E-2) | -      | 2E-14                               | 2E-8           | 2E-7                                   |
| 95         | Americium-244m <sup>2</sup>  | W, all compounds                          | 6E+4                           | 4E+3             | 2E-6   | -                                   | -              | -                                      |
|            |                              |   | St wall (8E+4)                 | Bone surf (7E+3) | -      | 1E-8                                | 1E-3           | 1E-2                                   |
| 95         | Americium-244                | W, all compounds                          | 3E+3                           | 2E+2             | 8E-8   | -                                   | 4E-5           | 4E-4                                   |
|            |                              |   | -                              | Bone surf (3E+2) | -      | 4E-10                               | -              | -                                      |
| 95         | Americium-245                | W, all compounds                          | 3E+4                           | 8E+4             | 3E-5   | 1E-7                                | 4E-4           | 4E-3                                   |
| 95         | Americium-246m <sup>2</sup>  | W, all compounds                          | 5E+4                           | 2E+5             | 8E-5   | 3E-7                                | -              | -                                      |
|            |                              |   | St wall (6E+4)                 | -                | -      | -                                   | 8E-4           | 8E-3                                   |
| 95         | Americium-246 <sup>2</sup>   | W, all compounds                          | 3E+4                           | 1E+5             | 4E-5   | 1E-7                                | 4E-4           | 4E-3                                   |
| 96         | Curium-238                   | W, all compounds                          | 2E+4                           | 1E+3             | 5E-7   | 2E-9                                | 2E-4           | 2E-3                                   |
| 96         | Curium-240                   | W, all compounds                          | 6E+1                           | 6E-1             | 2E-10  | -                                   | -              | -                                      |
|            |                              |   | Bone surf (8E+1)               | Bone surf (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 (5E+1)               | Bone surf (3E-1) | -      | 4E-13                               | 7E-7           | 7E-6                                   |
| 96         | Curium-243                   | W, all compounds                          | 1E+0                           | 9E-3             | 4E-12  | -                                   | -              | -                                      |
|            |                              |   | Bone surf (2E+0)               | Bone surf (1E-2) | -      | 2E-14                               | 3E-8           | 3E-7                                   |
| 96         | Curium-244                   | W, all compounds                          | 1E+0                           | 1E-2             | 5E-12  | -                                   | -              | -                                      |
|            |                              |   | Bone surf (3E+0)               | Bone surf (2E-2) | -      | 3E-14                               | 3E-8           | 3E-7                                   |
| 96         | Curium-245                   | W, all compounds                          | 7E-1                           | 6E-3             | 3E-12  | -                                   | -              | -                                      |
|            |                              |   | Bone surf (1E+0)               | Bone surf (1E-2) | -      | 2E-14                               | 2E-8           | 2E-7                                   |
| 96         | Curium-246                   | W, all compounds                          | 7E-1                           | 6E-3             | 3E-12  | -                                   | -              | -                                      |
|            |                              |   | Bone surf (1E+0)               | Bone surf (1E-2) | -      | 2E-14                               | 2E-8           | 2E-7                                   |
| 96         | Curium-247                   | W, all compounds                          | 8E-1                           | 6E-3             | 3E-12  | -                                   | -              | -                                      |
|            |                              |   | Bone surf (1E+0)               | Bone surf (1E-2) | -      | 2E-14                               | 2E-8           | 2E-7                                   |
| 96         | Curium-248                   | W, all compounds                          | 2E-1                           | 2E-3             | 7E-13  | -                                   | -              | -                                      |
|            |                              |   | Bone surf (4E-1)               | Bone surf (3E-3) | -      | 4E-15                               | 5E-9           | 5E-8                                   |
| 96         | Curium-249 <sup>2</sup>      | 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 (6E-2)               | Bone surf (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 (1E+0)               | Bone surf (9E-3) | -      | 1E-14                               | 2E-8           | 2E-7                                   |
| 97         | Berkelium-249                | W, all compounds                          | 2E+2                           | 2E+0             | 7E-10  | -                                   | -              | -                                      |
|            |                              |   | Bone surf (5E+2)               | Bone surf (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                      | -                | -      | -                                   | -              | -                                      |
| 98         | Californium-244 <sup>2</sup> | 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                               | -              | -                                      |

Appendix B

| Atomic No. | Radionuclide     | Class            | Table I<br>Occupational Values |                  |            | Table II<br>Effluent Concentrations |                | Table III<br>Releases to Sewers        |
|------------|------------------|------------------|--------------------------------|------------------|------------|-------------------------------------|----------------|--|
|            |                  |                  | Col. 1                         | Col. 2           | Col. 3     | Col. 1                              | Col. 2         | Monthly Average Concentration (µCi/ml) |
|            |                  |                  | Oral                           |                  |            | Air (µCi/ml)                        | Water (µCi/ml) |  |
|            |                  |                  | Ingestion                      |                  | Inhalation |                                     |                |  |
| ALI (µCi)  | ALI (µCi)        | DAC (µCi/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      | -                                   | -              | -                                      |
|            |                  | Y, see 244Cf     | Bone surf (2E+1)               | Bone surf (1E-1) | -          | 2E-13                               | 2E-7           | 2E-6                                   |
| 98         | Californium-249  | W, see 244Cf     | -                              | 1E-1             | 4E-11      | 1E-13                               | -              | -                                      |
|            |                  | Y, see 244Cf     | 5E-1                           | 4E-3             | 2E-12      | -                                   | -              | -                                      |
|            |                  |                  | Bone surf (1E+0)               | Bone surf (9E-3) | -          | 1E-14                               | 2E-8           | 2E-7                                   |
|            |                  |                  | Bone surf                      | 1E-2             | 4E-12      | -                                   | -              | -                                      |
| 98         | Californium-250  | W, see 244Cf     | -                              | (1E-2)           | -          | 2E-14                               | -              | -                                      |
|            |                  | Y, see 244Cf     | 1E+0                           | 9E-3             | 4E-12      | -                                   | -              | -                                      |
|            |                  | W, see 244Cf     | Bone surf (2E+0)               | Bone surf (2E-2) | -          | 3E-14                               | 3E-8           | 3E-7                                   |
| 98         | Californium-251  | W, see 244Cf     | -                              | 3E-2             | 1E-11      | 4E-14                               | -              | -                                      |
|            |                  | Y, see 244Cf     | 5E-1                           | 4E-3             | 2E-12      | -                                   | -              | -                                      |
|            |                  |                  | Bone surf (1E+0)               | Bone surf (9E-3) | -          | 1E-14                               | 2E-8           | 2E-7                                   |
|            |                  |                  | Bone surf                      | 1E-2             | 4E-12      | -                                   | -              | -                                      |
| 98         | Californium-252  | W, see 244Cf     | -                              | (1E-2)           | -          | 2E-14                               | -              | -                                      |
|            |                  | Y, see 244Cf     | 2E+0                           | 2E-2             | 8E-12      | -                                   | -              | -                                      |
|            |                  | W, see 244Cf     | Bone surf (5E+0)               | Bone surf (4E-2) | -          | 5E-14                               | 7E-8           | 7E-7                                   |
| 98         | Californium-253  | W, see 244Cf     | -                              | 3E-2             | 1E-11      | 5E-14                               | -              | -                                      |
|            |                  | Y, see 244Cf     | 2E+2                           | 2E+0             | 8E-10      | 3E-12                               | -              | -                                      |
|            |                  |                  | Bone surf (4E+2)               | -                | -          | -                                   | 5E-6           | 5E-5                                   |
| 98         | Californium-254  | W, see 244Cf     | -                              | 2E+0             | 7E-10      | 2E-12                               | -              | -                                      |
|            |                  | Y, see 244Cf     | 2E+0                           | 2E-2             | 9E-12      | 3E-14                               | 3E-8           | 3E-7                                   |
| 99         | Einsteinium-250  | W, all compounds | -                              | 2E-2             | 7E-12      | 2E-14                               | -              | -                                      |
|            |                  |                  | 4E+4                           | 5E+2             | 2E-7       | -                                   | 6E-4           | 6E-3                                   |
| 99         | Einsteinium-251  | W, all compounds | -                              | Bone surf (1E+3) | -          | 2E-9                                | -              | -                                      |
|            |                  |                  | 7E+3                           | 9E+2             | 4E-7       | -                                   | 1E-4           | 1E-3                                   |
| 99         | Einsteinium-253  | W, all compounds | -                              | Bone surf (1E+3) | -          | 2E-9                                | -              | -                                      |
| 99         | Einsteinium-254m | W, all compounds | 2E+2                           | 1E+0             | 6E-10      | 2E-12                               | 2E-6           | 2E-5                                   |
|            |                  |                  | 3E+2                           | 1E+1             | 4E-9       | 1E-11                               | -              | -                                      |
| 99         | Einsteinium-254  | W, all compounds | LLI wall (3E+2)                | -                | -          | -                                   | 4E-6           | 4E-5                                   |
|            |                  |                  | 8E+0                           | 7E-2             | 3E-11      | -                                   | -              | -                                      |
| 100        | Fermium-252      | W, all compounds | Bone surf (2E+1)               | Bone surf (1E-1) | -          | 2E-13                               | 2E-7           | 2E-6                                   |
| 100        | Fermium-253      | W, all compounds | 5E+2                           | 1E+1             | 5E-9       | 2E-11                               | 6E-6           | 6E-5                                   |
| 100        | Fermium-254      | W, all compounds | 1E+3                           | 1E+1             | 4E-9       | 1E-11                               | 1E-5           | 1E-4                                   |
| 100        | Fermium-255      | W, all compounds | 3E+3                           | 9E+1             | 4E-8       | 1E-10                               | 4E-5           | 4E-4                                   |
| 100        | Fermium-257      | W, all compounds | 5E+2                           | 2E+1             | 9E-9       | 3E-11                               | 7E-6           | 7E-5                                   |
|            |                  |                  | 2E+1                           | 2E-1             | 7E-11      | -                                   | -              | -                                      |
| 101        | Mendelevium-257  | W, all compounds | Bone surf (4E+1)               | Bone surf (2E-1) | -          | 3E-13                               | 5E-7           | 5E-6                                   |
|            |                  |                  | 7E+3                           | 8E+1             | 4E-8       | -                                   | 1E-4           | 1E-3                                   |
| 101        | Mendelevium-258  | W, all compounds | -                              | Bone surf (9E+1) | -          | 1E-10                               | -              | -                                      |
|            |                  |                  | 3E+1                           | 2E-1             | 1E-10      | -                                   | -              | -                                      |
|            |                  |                  | Bone surf (5E+1)               | Bone surf (3E-1) | -          | 5E-13                               | 6E-7           | 6E-6                                   |
|            |                  |                  | -                              | 2E+2             | 1E-7       | 1E-9                                | -              | -                                      |
|            |                  |                  | -                              | 2E-1             | 1E-10      | 1E-12                               | 1E-8           | 1E-7                                   |
|            |                  |                  | -                              | 4E-4             | 2E-13      | 1E-15                               | 2E-9           | 2E-8                                   |

-Any single radionuclide not listed above with decay mode other than alpha emission or spontaneous fission and with radioactive half-life less than 2 hours  
 -Any single radionuclide not listed above with decay mode other than alpha emission or spontaneous fission and with radioactive half-life greater than 2 hours  
 -Any single radionuclide not listed above that decays by alpha emission or spontaneous fission, or any mixture for which either the identity or the concentration of any radionuclide in the mixture is not known

FOOTNOTES:

- "Submersion" means that values given are for submersion in a hemispherical semi-infinite cloud of airborne material.
- These radionuclides have radiological half-lives of less than 2 hours. The total effective dose equivalent received during operations with these radionuclides might include a significant contribution from external exposure. The DAC values for all radionuclides, other than those designated Class "Submersion," are based upon the committed effective dose equivalent due to the intake of the radionuclide into the body and do NOT include potentially significant contributions to dose equivalent from external exposures. The licensee may substitute 1E-7 µCi/ml for the listed DAC to account for the submersion dose prospectively, but should use individual monitoring devices or other radiation measuring instruments that measure external exposure to demonstrate compliance with the limits. (See 20.1203.)
- 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:  
 $SA = 3.6E-7 \text{ curies/gram U} \quad \text{U-depleted}$   
 $SA = [0.4 + 0.38 (\text{enrichment}) + 0.0034 (\text{enrichment})^2] E-6, \text{ enrichment} \geq 0.72$   
 where enrichment is the percentage by weight of U-235, expressed as percent.

NOTES:

- 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.
- 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

| Atomic | No. | Radionuclide | Class | Table I<br>Occupational Values |            |        | Table II<br>Effluent Concentrations |          | Table III<br>Releases to Sewers |
|--------|-----|--------------|-------|--------------------------------|------------|--------|-------------------------------------|----------|---------------------------------|
|        |     |              |       | Col. 1                         | Col. 2     | Col. 3 | Col. 1                              | Col. 2   | Monthly Average Concentration   |
|        |     |              |       | Oral Ingestion                 |            |        | Air                                 | Water    |                                 |
|        |     |              |       | ALI                            | Inhalation |        | (µCi/ml)                            | (µCi/ml) | (µCi/ml)                        |
|        |     |              |       | (µCi)                          | ALI        | DAC    | (µCi/ml)                            | (µCi/ml) | (µCi/ml)                        |

If it is known that Ac-227-D and Cm-250-W are not present  
 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  
 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-4 | 3E-13 | - | - | - |
| - | 7E-3 | 3E-12 | - | - | - |
| - | 7E-2 | 3E-11 | - | - | - |

## Appendix B

| Atomic<br>No. | Radionuclide | Class | Table I             |              |                 | Table II<br>Effluent<br>Concentrations |                   | Table III<br>Releases to<br>Sewers  |  |
|---------------|--------------|-------|---------------------|--------------|-----------------|--|-------------------|-------------------------------------|--|
|               |              |       | Col. 1              | Col. 2       | Col. 3          | Col. 1                                 | Col. 2            |                                     |  |
|               |              |       | Occupational Values |              |                 |  |                   |                                     |  |
|               |              |       | Oral                |              |                 | Inhalation                             |                   | Monthly<br>Average<br>Concentration |  |
|               |              |       | ALI<br>(μCi)        | ALI<br>(μCi) | DAC<br>(μCi/ml) | Air<br>(μCi/ml)                        | Water<br>(μCi/ml) | (μCi/ml)                            |  |

If, in addition, it is known that Pb-210-D, Bi-210m-W, Po-210-D,W, Ra-223-W, Ra-225-W, Ra-226-W, Ac-225-D,W,Y, Th-227-W,Y, U-230-D,W,Y, U-232-D,W, Pu-241-W, Cm-240-W, Cm-242-W, Cf-248-Y, Es-254-W, Fm-257-W, and Md-258-W are not present

-      7E-1      3E-10

If, in addition, it is known that Si-32-Y, Ti-44-Y, Fe-60-D, Sr-90-Y, Zr-93-D, Cd-113m-D, Cd-113-D, In-115-D,W, La-138-D, Lu-176-W, Hf-178m-D,W, Hf-182-D,W, Bi-210m-D, Ra-224-W, Ra-228-W, Ac-226-D,W,Y, Pa-230-W,Y, U-233-D,W, U-234-D,W, U-235-D,W, U-236-D,W, U-238-D,W, Pu-241-Y, Bk-249-W, Cf-253-W,Y, and Es-253-W are not present

-      7E+0      3E-9

If it is known that Ac-227-D,W,Y, Th-229-W,Y, Th-232-W,Y, Pa-231-W,Y, Cm-248-W, and Cm-250-W are not present

-      -      -      1E-14      -

If, in addition, it is known that Sm-146-W, Gd-148-D,W, Gd-152-D, Th-228-W,Y, Th-230-W,Y, U-232-Y, U-233-Y, U-234-Y, U-235-Y, U-236-Y, U-238-Y, U-Nat-Y, Np-236-W, Np-237-W, Pu-236-W,Y, Pu-238-W,Y, Pu-239-W,Y, Pu-240-W,Y, Pu-242-W,Y, Pu-244-W,Y, Am-241-W, Am-242m-W, Am-243-W, Cm-243-W, Cm-244-W, Cm-245-W, Cm-246-W, Cm-247-W, Bk-247-W, Cf-249-W,Y, Cf-250-W,Y, Cf-251-W,Y, Cf-252-W,Y, and Cf-254-W,Y are not present

-      -      -      1E-13      -

If, in addition, it is known that Sm-147-W, Gd-152-W, Pb-210-D, Bi-210m-W, Po-210-D,W, Ra-223-W, Ra-225-W, Ra-226-W, Ac-225-D,W,Y, Th-227-W,Y, U-230-D,W,Y, U-232-D,W, U-Nat-W, Pu-241-W, Cm-240-W, Cm-242-W, Cf-248-W,Y, Es-254-W, Fm-257-W, and Md-258-W are not present

-      -      -      1E-12      -

If, in addition it is known that Fe-60, Sr-90, Cd-113m, Cd-113, In-115, I-129, Cs-134, Sm-145, Sm-147, Gd-148, Gd-152, Hg-194 (organic), Bi-210m, Ra-223, Ra-224, Ra-225, Ac-225, Th-228, Th-230, U-233, U-234, U-235, U-236, U-238, U-Nat, Cm-242, Cf-248, Es-254, Fm-257, and Md-258 are not present

-      -      -      -      1E-6      1E-5

### 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:

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

## APPENDIX C

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

| Radionuclide  | Quantity<br>( $\mu$ Ci)* | Radionuclide  | Quantity<br>( $\mu$ Ci)* |
|---------------|--------------------------|---------------|--------------------------|
| Hydrogen-3    | 1,000                    | Chromium-48   | 1,000                    |
| Beryllium-7   | 1,000                    | Chromium-49   | 1,000                    |
| Beryllium-10  | 1                        | Chromium-51   | 1,000                    |
| Carbon-11     | 1,000                    | Manganese-51  | 1,000                    |
| Carbon-14     | 100                      | Manganese-52m | 1,000                    |
| Fluorine-18   | 1,000                    | Manganese-52  | 100                      |
| Sodium-22     | 10                       | Manganese-53  | 1,000                    |
| Sodium-24     | 100                      | Manganese-54  | 100                      |
| Magnesium-28  | 100                      | Manganese-56  | 1,000                    |
| Aluminum-26   | 10                       | Iron-52       | 100                      |
| Silicon-31    | 1,000                    | Iron-55       | 100                      |
| Silicon-32    | 1                        | Iron-59       | 10                       |
| Phosphorus-32 | 10                       | Iron-60       | 1                        |
| Phosphorus-33 | 100                      | Cobalt-55     | 100                      |
| Sulfur-35     | 100                      | Cobalt-56     | 10                       |
| Chlorine-36   | 10                       | Cobalt-57     | 100                      |
| Chlorine-38   | 1,000                    | Cobalt-58m    | 1,000                    |
| Chlorine-39   | 1,000                    | Cobalt-58     | 100                      |
| Argon-39      | 1,000                    | Cobalt-60m    | 1,000                    |
| Argon-41      | 1,000                    | Cobalt-60     | 1                        |
| Potassium-40  | 100                      | Cobalt-61     | 1,000                    |
| Potassium-42  | 1,000                    | Cobalt-62m    | 1,000                    |
| Potassium-43  | 1,000                    | Nickel-56     | 100                      |
| Potassium-44  | 1,000                    | Nickel-57     | 100                      |
| Potassium-45  | 1,000                    | Nickel-59     | 100                      |
| Calcium-41    | 100                      | Nickel-63     | 100                      |
| Calcium-45    | 100                      | Nickel-65     | 1,000                    |
| Calcium-47    | 100                      | Nickel-66     | 10                       |
| Scandium-43   | 1,000                    | Copper-60     | 1,000                    |
| Scandium-44m  | 100                      | Copper-61     | 1,000                    |
| Scandium-44   | 100                      | Copper-64     | 1,000                    |
| Scandium-46   | 10                       | Copper-67     | 1,000                    |
| Scandium-47   | 100                      | Zinc-62       | 100                      |
| Scandium-48   | 100                      | Zinc-63       | 1,000                    |
| Scandium-49   | 1,000                    | Zinc-65       | 10                       |
| Titanium-44   | 1                        | Zinc-69m      | 100                      |
| Titanium-45   | 1,000                    | Zinc-69       | 1,000                    |
| Vanadium-47   | 1,000                    | Zinc-71m      | 1,000                    |
| Vanadium-48   | 100                      | Zinc-72       | 100                      |
| Vanadium-49   | 1,000                    | Gallium-65    | 1,000                    |

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

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

| Radionuclide | Quantity<br>( $\mu$ Ci)* | Radionuclide  | Quantity<br>( $\mu$ Ci)* |
|--------------|--------------------------|---------------|--------------------------|
| Gallium-66   | 100                      | Krypton-81    | 1,000                    |
| Gallium-67   | 1,000                    | Krypton-83m   | 1,000                    |
| Gallium-68   | 1,000                    | Krypton-85m   | 1,000                    |
| Gallium-70   | 1,000                    | Krypton-85    | 1,000                    |
| Gallium-72   | 100                      | Krypton-87    | 1,000                    |
| Gallium-73   | 1,000                    | Krypton-88    | 1,000                    |
| Germanium-66 | 1,000                    | Rubidium-79   | 1,000                    |
| Germanium-67 | 1,000                    | Rubidium-81m  | 1,000                    |
| Germanium-68 | 10                       | Rubidium-81   | 1,000                    |
| Germanium-69 | 1,000                    | Rubidium-82m  | 1,000                    |
| Germanium-71 | 1,000                    | Rubidium-83   | 100                      |
| Germanium-75 | 1,000                    | Rubidium-84   | 100                      |
| Germanium-77 | 1,000                    | Rubidium-86   | 100                      |
| Germanium-78 | 1,000                    | Rubidium-87   | 100                      |
| Arsenic-69   | 1,000                    | Rubidium-88   | 1,000                    |
| Arsenic-70   | 1,000                    | Rubidium-89   | 1,000                    |
| Arsenic-71   | 100                      | Strontium-80  | 100                      |
| Arsenic-72   | 100                      | Strontium-81  | 1,000                    |
| Arsenic-73   | 100                      | Strontium-83  | 100                      |
| Arsenic-74   | 100                      | Strontium-85m | 1,000                    |
| Arsenic-76   | 100                      | Strontium-85  | 100                      |
| Arsenic-77   | 100                      | Strontium-87m | 1,000                    |
| Arsenic-78   | 1,000                    | Strontium-89  | 10                       |
| Selenium-70  | 1,000                    | Strontium-90  | 0.1                      |
| Selenium-73m | 1,000                    | Strontium-91  | 100                      |
| Selenium-73  | 100                      | Strontium-92  | 100                      |
| Selenium-75  | 100                      | Yttrium-86m   | 1,000                    |
| Selenium-79  | 100                      | Yttrium-86    | 100                      |
| Selenium-81m | 1,000                    | Yttrium-87    | 100                      |
| Selenium-81  | 1,000                    | Yttrium-88    | 10                       |
| Selenium-83  | 1,000                    | Yttrium-90m   | 1,000                    |
| Bromine-74m  | 1,000                    | Yttrium-90    | 10                       |
| Bromine-74   | 1,000                    | Yttrium-91m   | 1,000                    |
| Bromine-75   | 1,000                    | Yttrium-91    | 10                       |
| Bromine-76   | 100                      | Yttrium-92    | 100                      |
| Bromine-77   | 1,000                    | Yttrium-93    | 100                      |
| Bromine-80m  | 1,000                    | Yttrium-94    | 1,000                    |
| Bromine-80   | 1,000                    | Yttrium-95    | 1,000                    |
| Bromine-82   | 100                      | Zirconium-86  | 100                      |
| Bromine-83   | 1,000                    | Zirconium-88  | 10                       |
| Bromine-84   | 1,000                    | Zirconium-89  | 100                      |
| Krypton-74   | 1,000                    | Zirconium-93  | 1                        |
| Krypton-76   | 1,000                    | Zirconium-95  | 10                       |
| Krypton-77   | 1,000                    | Zirconium-97  | 100                      |
| Krypton-79   | 1,000                    | Niobium-88    | 1,000                    |

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

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

| Radionuclide         | Quantity<br>( $\mu$ Ci)* | Radionuclide       | Quantity<br>( $\mu$ Ci)* |
|----------------------|--------------------------|--------------------|--------------------------|
| 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  $\mu$ Ci to kBq, multiply the  $\mu$ Ci value by 37.

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

| Radionuclide         | Quantity<br>( $\mu$ Ci)* | Radionuclide | Quantity<br>( $\mu$ Ci)* |
|----------------------|--------------------------|--------------|--------------------------|
| 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 (9.01h) | 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  $\mu$ Ci to kBq, multiply the  $\mu$ Ci value by 37.

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

| Radionuclide      | Quantity<br>( $\mu\text{Ci}$ )* | Radionuclide          | Quantity<br>( $\mu\text{Ci}$ )* |
|-------------------|---------------------------------|-----------------------|---------------------------------|
| 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  $\mu\text{Ci}$  to kBq, multiply the  $\mu\text{Ci}$  value by 37.

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

| Radionuclide         | Quantity<br>( $\mu$ Ci)* | Radionuclide  | Quantity<br>( $\mu$ Ci)* |
|----------------------|--------------------------|---------------|--------------------------|
| 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 (5.0h)  | 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  $\mu$ Ci to kBq, multiply the  $\mu$ Ci value by 37.

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

| Radionuclide        | Quantity<br>( $\mu$ Ci)* | Radionuclide  | Quantity<br>( $\mu$ Ci)* |
|---------------------|--------------------------|---------------|--------------------------|
| 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 (64.0h) | 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  $\mu$ Ci to kBq, multiply the  $\mu$ Ci value by 37.

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

| Radionuclide | Quantity<br>( $\mu$ Ci)* | Radionuclide            | Quantity<br>( $\mu$ Ci)* |
|--------------|--------------------------|-------------------------|--------------------------|
| 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  $\mu$ Ci to kBq, multiply the  $\mu$ Ci value by 37.

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

| Radionuclide  | Quantity<br>( $\mu$ Ci)* | Radionuclide   | Quantity<br>( $\mu$ Ci)* |
|---|--------------------------|--|--------------------------|
| 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 radionuclide not listed above or mixtures of alpha emitters of unknown composition | 0.001                    | Any radionuclide other than alpha-emitting radionuclides not listed above, or mixtures of beta emitters of unknown composition | 0.01                     |

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

**NOTE:** For purposes of D.28.E, D.31.A, and D.51.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.

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

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## 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, 10 State House Station, Augusta, Maine 04333-0010
- D. This appendix includes information requirements of the 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.

## Appendix D

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 chapter, 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) who offers low-level radioactive waste for transportation, typically consigning this type of waste to a licensed waste collector, waste processor, or land disposal facility operator.
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, who
  - (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, whose principal purpose is to process, repack, 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:

## Appendix D

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 sorbing or solidification media, if any, and the identity of the solidification media vendor and brand name;
10. The identities and activities of individual radionuclides contained in each container, the masses of U-233, U-235, and plutonium in special nuclear material, and the masses of uranium and thorium in source material. For discrete waste types (i.e., activated materials, contaminated equipment, mechanical filters, sealed source/devices, and wastes in solidification/stabilization media), the identities and activities of individual radionuclides associated with or contained 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 sorbing or solidification media, if any, and the identity of the solidification media vendor and brand name if the media is claimed to meet stability requirements in 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 than 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 these regulations; 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;

## Appendix D

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 these regulations;
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 who treats or repackages waste shall:

1. Acknowledge receipt of the waste from the shipper within one week of receipt by returning a signed copy of 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 these regulations;
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 2 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) whose potential hazard will persist long after such precautions as institutional controls, improved waste form, and deeper disposal have ceased to be effective. These precautions delay the time when long-lived radionuclides could cause exposures. In addition, the magnitude of the potential dose is limited by the concentration and availability of the radionuclide at the time of exposure. Second, consideration must be given to the concentration of shorter-lived radionuclides for which requirements on institutional controls, waste form, and disposal methods are effective.

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

| 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 | <sup>1</sup> 100                     |
| Pu-241  | <sup>1</sup> 3,500                   |
| Cm-242  | <sup>1</sup> 20,000                  |

<sup>1</sup>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.

- If the concentration does not exceed the value in Column 1, the waste is Class A.
- If the concentration exceeds the value in Column 1, but does not exceed the value in Column 2, the waste is Class B.
- If the concentration exceeds the value in Column 2, but does not exceed the value in Column 3, the waste is Class C.
- If the concentration exceeds the value in Column 3, the waste is not generally acceptable for near-surface disposal.
- For wastes containing mixtures of the nuclides listed in Table 2, the total concentration shall be determined by the sum of fractions rule

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

<sup>1</sup> 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 radionuclides 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/m<sup>3</sup>. and Cs-137 in a concentration of 22 Ci/m<sup>3</sup>. 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% 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 20°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 chapter 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 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 these regulations 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.
- I. 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.

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**APPENDIX E**

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**Appendix F**

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## APPENDIX 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:
  - (1) 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 7-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 7 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 1 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

- A. Packaging and waste form of waste for disposal will comply with the requirements of the licensed or registered receiving Radioactive Waste Site or Authority.